1146 Issued April 26, 1909.

U. S. DEPARTMENT OF AGRICULTURE.
OFFICE OF EXPERIMENT STATIONS—BULLETIN 209.
A. C. TRUE, Director.

IRRIGATION IN OREGON.

BY

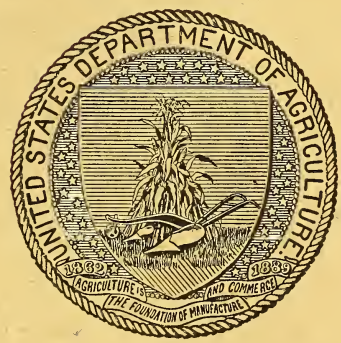
JOHN H. LEWIS,
State Engineer,

ASSISTED BY

PERCY A. CUPPER.

PREPARED UNDER THE DIRECTION OF

SAMUEL FORTIER,
Chief of Irrigation Investigations.



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*Bul. 58. Water Rights on the Missouri River and its Tributaries. By Elwood Mead. Pp. 80.

*Bul. 60. Abstract of Laws for Acquiring Titles to Water from the Missouri River and its Tributaries, with the Legal Forms in Use. Compiled by Elwood Mead. Pp. 77.

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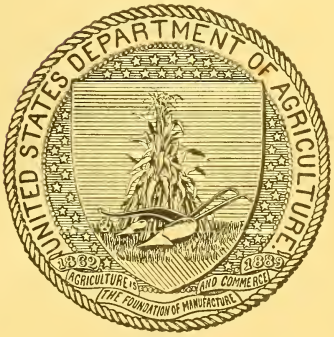

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Samuel Fortier, Chief.
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LETTER OF TRANSMITTAL.

UNITED STATES DEPARTMENT OF AGRICULTURE,
OFFICE OF EXPERIMENT STATIONS,
Washington, D. C., April 1, 1909.

SIR: I have the honor to transmit herewith a report on irrigation in Oregon, prepared by John H. Lewis, State engineer of that State, assisted by Percy A. Cupper. This is one of a series of reports dealing with irrigation in the arid States and Territories prepared for the purpose of answering the inquiries regarding the opportunities and cost of settlement which come to this Department in great numbers. It is recommended that this report be published as a bulletin of this Office.

Respectfully,

A. C. TRUE.
Director.

Hon. JAMES WILSON,
Secretary of Agriculture.

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IRRIGATION IN OREGON.

GENERAL DESCRIPTION.

Oregon is approximately rectangular in shape, having a coast line of 305 miles and extending inland 375 miles. Its total area, including water surfaces, is 96,699 square miles, or 61,887,360 acres. This is 2,250,000 acres greater than the combined areas of New York, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut, New Jersey, and Delaware. The population in 1900 was 413,000, or a little more than four persons to the square mile, as compared with Rhode Island with 400 to the square mile.

The total value of taxable property in 1907 was $581,558,918.

Oregon has over 2,000 miles of railway lines, located exclusively in the northern and western portions. (Pl. I.) The State contains the largest area of land without railroad transportation of any State in the Union. This undeveloped area is approximately 250 miles square, with eleven railroad spurs heading toward its center. Extensions are being made at the present time on several of these, and within the next few years this section will be relieved in part.

Nearly one-third of the State's area is vacant public land, open to entry under the various land laws of the United States.

The Columbia River is navigable at the present time to The Dalles, and with the completion of the government canal and locks just above that point will be open to navigation for a much greater distance. The Willamette River is navigable to Eugene. Along the coast are numerous harbors of great promise.

TOPOGRAPHY.

The topography of Oregon gives rise to sharp contrasts in the agricultural possibilities of different portions of the State. The most striking feature is the Cascade Range, which parallels the coast about 125 miles inland and divides the State into two parts, which differ widely in climate, topography, and future possibilities. East of this range but little rainfall occurs and irrigation is necessary, while west of it the annual precipitation is heavy though unevenly distributed. The range itself consists of a series of peaks of volcanic origin, 6,000 to 11,200 feet in elevation, Mount Hood, in the

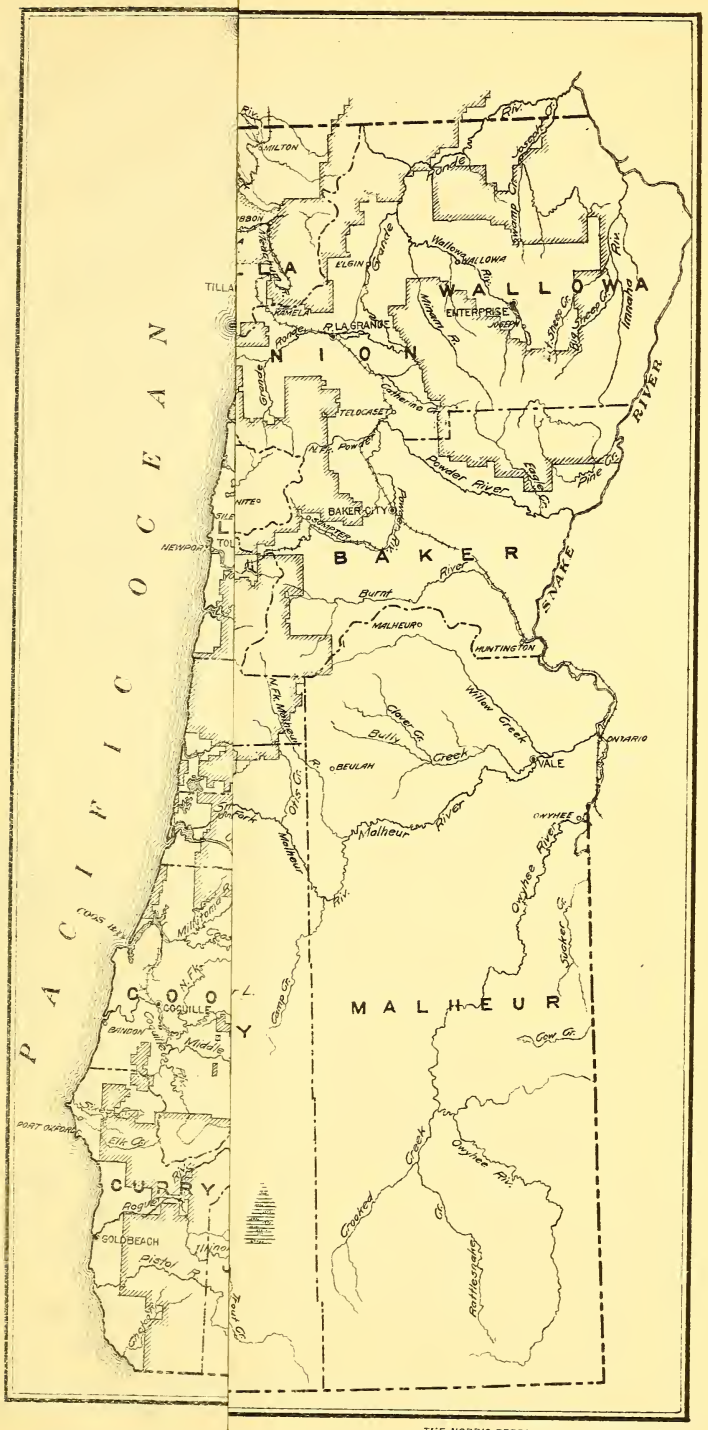
northern part of the State, being the highest. Crater Lake, at the southern end of this range, is 5 miles in diameter and is at an elevation of 7,000 feet. It is located in the crater of an extinct volcano, having a depth of 2,000 feet and its water surface is 1,000 feet below the rim of the crater. Many of these peaks are covered perpetually with snow.

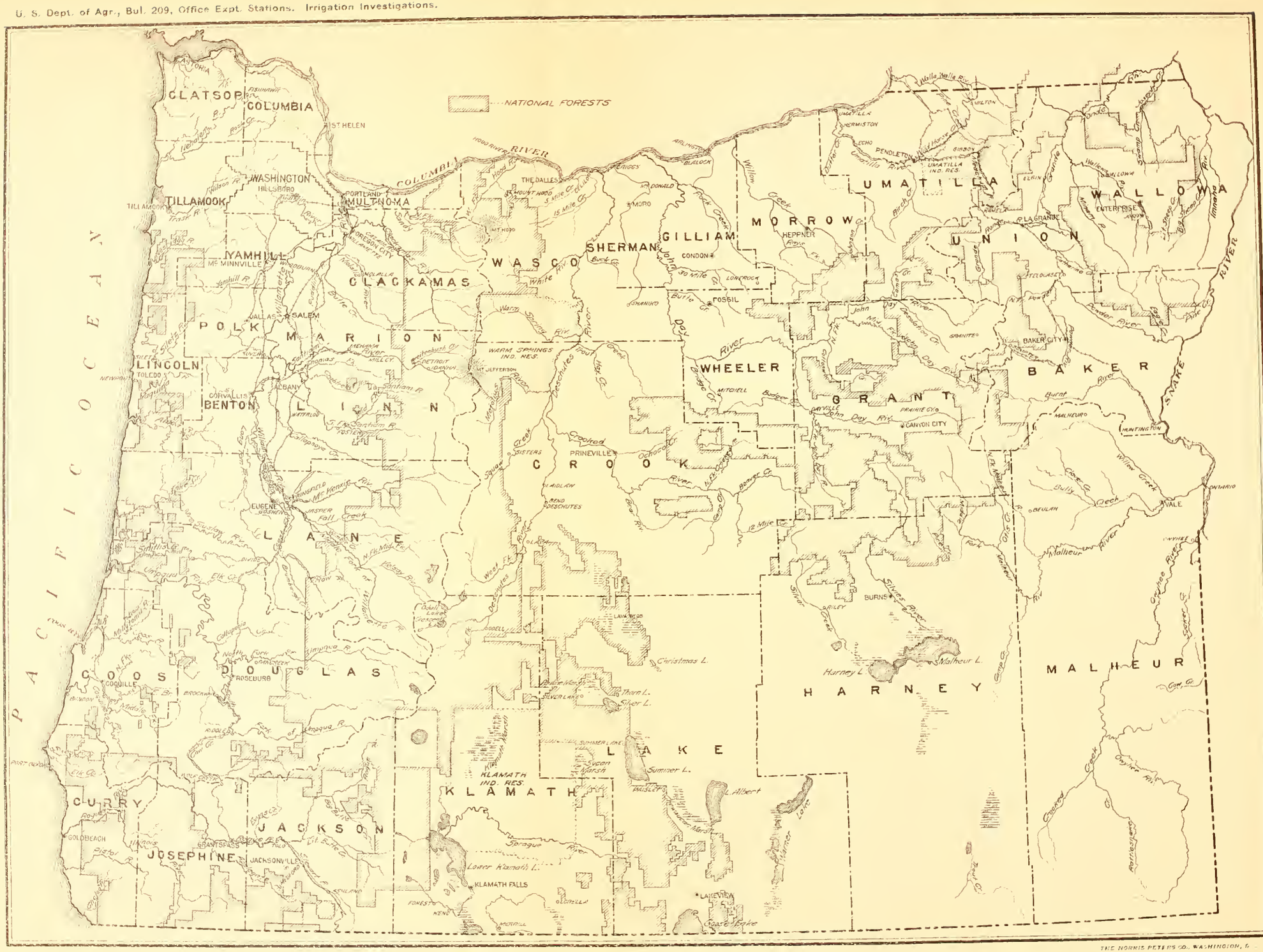
The western slope of this range drops to near sea level within a distance of about 40 miles and furnishes almost unlimited opportunity for water-power development. (Figs. 1 and 2, p. 10). The Coast Range, which is of lower elevation, also parallels the ocean, forming, in the northern portion of the State, between these two ranges, the broad Willamette Valley, having a drainage area of 12,200 square miles. This valley drains to the north into the Columbia River and contains an area of more than 2,500,000 acres of most fertile land, having an average elevation of approximately 200 feet. The Coast Range is cut through in southern Oregon by Umpqua and Rogue rivers, which drain the west slope of the Cascade Mountains and flow directly into the Pacific Ocean. This portion of the State is therefore considerably broken. Rogue River Valley, in the vicinity of Medford and Ashland, is the most extensive valley in this region. Still farther south on the State line the Klamath River breaks through both these ranges and drains a large area of central Oregon lying on the edge of the high plateau region.

Both the Cascade and Coast Range mountains extend to the north into Washington, but are cut through by the Columbia River, which forms the northern boundary of the State for 300 miles. The Snake River, a tributary of the Columbia, forms the boundary line on the east, between Oregon and Idaho for 140 miles. Portland, located at the junction of the Willamette and Columbia rivers, is a fresh-water port 100 miles above Astoria, at the mouth of the Columbia River. The depth of water on the bar is the controlling feature in navigation on the Columbia River. This depth is now 34 feet at high tide, as compared with 34½ feet for New York Harbor.

Eastern Oregon, comprising about two-thirds of the State's area, is distinctly arid, except for the forest growth of pine in the rough mountainous districts near the Idaho line. The territory along the Columbia River, 155 miles in length by 20 to 50 miles in width, has a gradual slope to the north, except where cut through by Deschutes, John Day, and Umatilla rivers. The rainfall in eastern Oregon is sufficient to mature a good crop of wheat every second year. The soil is a light volcanic ash, which plows easily as compared with the heavy clay soils in western Oregon.

The southern half of eastern Oregon is practically all above 4,000 feet in elevation. Owing to the absence of railroad transportation, but little settlement and development has taken place. It has not





MAP OF OREGON SHOWING STREAMS AVAILABLE FOR IRRIGATION.

as yet been fully determined whether the precipitation is sufficient to mature regularly profitable grain crops.

The great majority of Oregon's population is located in the semi-humid, forest-covered area west of the Cascade Range.

Topographic maps covering about 15,000 square miles of the State's area have been made during the past four years by the U. S. Geological Survey. These maps are issued in quadrangle sheets covering an area generally 15 square miles in extent and are designated by the following names: Klamath, Ashland, Grants Pass, Riddles, Roseburg, Coos Bay, Port Orford, in southwestern Oregon; Mitchell Butte, Sumpter, Baker City, Telocaset, in eastern Oregon; and Portland, Blalock Island, and Umatilla, in the northern part of the State. The maps can be secured for 5 cents each by addressing the Director, U. S. Geological Survey, Washington, D. C. The geological formation has been worked out for the Coos Bay, Port Orford, Roseburg, and Sumpter sheets, and the geological folios for these districts can be secured for 25 cents each.

A general idea of the relative elevations of the different portions of the State is given by the following table. The elevation for each town is that of the bench mark established by precise level surveys by the U. S. Geological Survey.

Elevations of important points in Oregon.

Place.	Elevation above sea level.	Place.	Elevation above sea level.
	Feet.		*Feet.*
Ashland	1,874	Arlington	226
Medford	1,376	Umatilla	295
Grants Pass	956	Echo	638
Wolf Creek, summit of divide	1,516	Pendleton	1,078
Roseburg	464	Kamela, summit of Blue Mountains	4,206
Divide	690	La Grande	2,787
Eugene	449	Baker City	3,440
Albany	212	Sumpter	4,423
Salem	171	Granite	4,688
Woodburn	182	Ontario	2,151
Oregon City	75	Vale	2,242
Portland	54	Huntington	2,113
Burns	4,185	Prineville	2,867
Shaniko	3,341	Hood River	103
The Dalles	103		

CLIMATE.

Oregon is particularly free from destructive wind and thunder storms. The chief feature characterizing the temperature of the entire State is the coolness which exists at night during the summer time.

In the coast counties the records of the U. S. Weather Bureau fail to show the temperature ever having reached 100° F. in the summer or having gone below zero in the winter. At Newport only 11½° difference is found between the average winter and average

summer temperatures. The average date of first killing frost in autumn is December 28, and of the last in the spring March 22. The average growing season is thus 282 days. This fact doubtless accounts for the great success which attends dairying in these coast counties. Between the Coast Range and Cascade Mountains there are greater variations in temperature. At Portland the high-

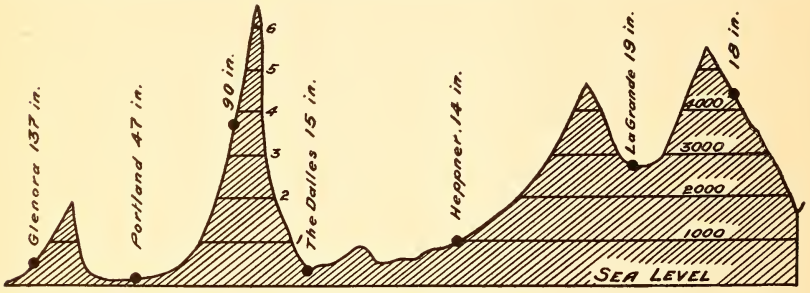


FIG. 1.—Typical east and west cross section through northern Oregon, showing variation in annual rainfall with changes of elevation.

est temperature occurring during a thirty-year period was 102° F. and the minimum 2°. The average growing season without killing frost is 213 days.

East of the Cascade Mountains still greater fluctuations in annual temperature occur. At Pendleton, the average growing season is 150 days, and in low valleys of the high plateau region killing frosts are likely to occur any month in the year.

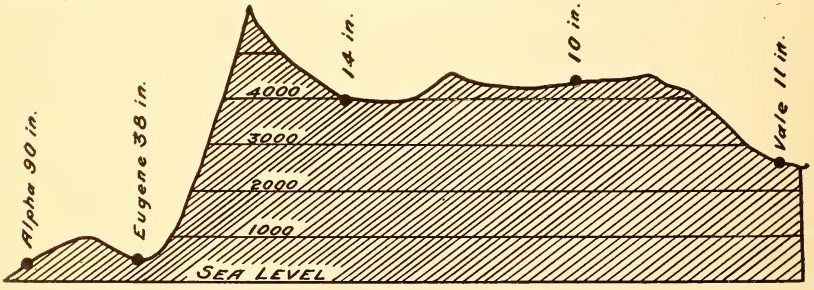


FIG. 2.—Typical east and west cross section through central and southern Oregon, showing variation in annual rainfall with changes of elevation.

In no other State is there so great a variation in rainfall. At Prineville, in the central portion of the State, the annual rainfall is 8 inches, while at Glenora, on the northern coast, it is 137 inches, the heaviest recorded by the U. S. Weather Bureau for any point in the United States. The variation in rainfall from west to east, with reference to changes in elevations, is shown by figures 1 and 2. The heaviest precipitation occurs on the west slope of the Coast Range and Cascade Mountains, as little moisture escapes to be con-

densed over the eastern portion of the State. The annual rainfall at Portland, according to the latest Weather Bureau figures, is 47 inches. From Portland the annual rainfall gradually decreases east and south. At The Dalles, 75 miles east of Portland, it is but 15 inches, while at Pendleton it is 14 inches. At Ashland, 225 miles south, it is only 20 inches, and at Burns, in the center of the high

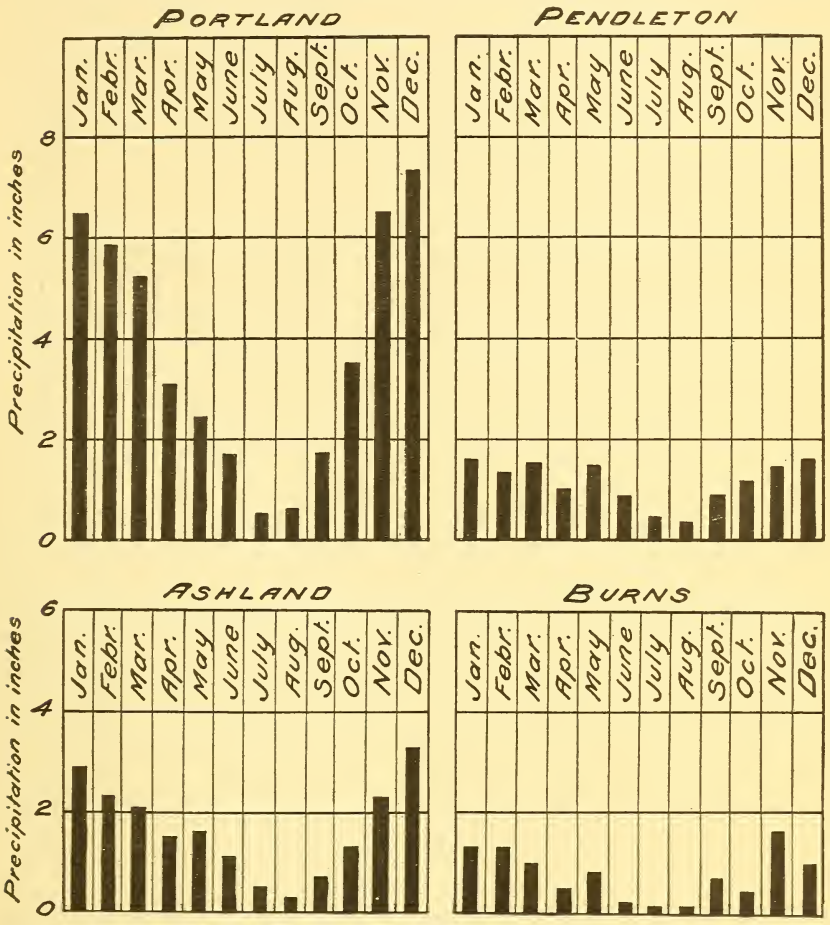


FIG. 3.—Mean monthly precipitation at typical stations in each quarter of the State of Oregon. From U. S. Weather Bureau records.

plateau region, it is only 10 inches. These variations are shown graphically by figure 3, which shows also the precipitation each month.

It is evident from an examination of the rainfall records that Oregon has clearly defined wet and dry seasons, and from a detailed examination of the run-off statistics it is observed that the low-water flow occurs during the summer months, coincident with the

shortage of rainfall. In a few exceptional streams flowing from the east slope of the high Cascade Range the highest floods occur in the summer time, being caused by the melting of snow in the mountains. For the production of crops the seasonal distribution of rainfall is of more importance than the total amount. By examining the monthly rainfall diagram for Portland, which is typical of the humid portion of the State, it will be noted that during the summer, or crop-growing season, essentially arid conditions prevail. The average precipitation during June, July, and August for the Willamette Valley is but 2.5 inches. This is less than the rainfall which occurs at Baker City, La Grande, Joseph, and other points in eastern Oregon during the same period.

The temperature and precipitation records of the State are summarized in the following table:

Temperature and precipitation.[a]

Station.	Mean annual temperature.	Frost, average date of—		Precipitation.				
		First killing in autumn.	Last in spring.	Spring.	Summer.	Autumn.	Winter.	Total annual.
Western Oregon:	°F.			*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
Astoria	52	Nov. 25	Mar. 13	17.9	5.7	21.5	33.1	78.2
Glenora	49	Oct. 18	May 16	31.8	6.2	40.1	58.2	136.3
Portland	53	Nov. 16	Mar. 17	10.7	3.0	11.9	20.0	45.6
Newport	51	Dec. 28	Mar. 22	19.3	4.6	20.4	28.9	73.2
Albany	53	Nov. 4	Mar. 27	10.9	2.0	11.5	19.8	44.2
Bandon	51	Nov. 25	Mar. 10	16.8	3.4	15.8	31.2	67.2
Roseburg	53	Oct. 30	Apr. 15	8.2	2.0	8.0	16.7	34.9
Ashland	52	Oct. 14	Apr. 18	5.1	2.2	4.6	8.3	20.2
Eastern Oregon:								
The Dalles	52	Nov. 3	Apr. 6	2.6	.9	4.1	7.8	15.4
Lone Rock	46	Sept. 16	June 23	4.5	2.2	3.5	4.4	14.6
Pendleton	52	Oct. 3	May 7	4.2	1.8	3.8	4.7	14.5
Joseph	42	Sept. 7	June 17	5.0	3.3	4.6	4.9	17.8
Prineville	49	.....	.....	2.5	1.2	2.1	2.4	8.2
Dayville	50	Sept. 25	May 26	3.9	1.1	3.2	4.1	12.3
Baker City	45	Sept. 26	June 1	4.0	2.0	2.9	4.3	13.2
Beulah	46	Sept. 3	June 28	3.1	.9	2.5	4.6	11.1
Silver Lake	44	.....	.....	3.1	1.6	2.7	3.0	10.4
Happy Valley	45	Sept. 1	June 17	5.0	4.7	3.1	3.9	16.7
Lakeview	46	.....	.....	4.8	1.8	3.6	6.8	17.0

[a] From U. S. Weather Bureau Bul. 361.

WATER RESOURCES.

On account of the exceptional rainfall which occurs on the Cascade and Coast Range mountains, and the rapidity with which these mountains slope to sea level, the water resources of Oregon for both power and irrigation purposes are great.

The average run-off from the entire State is about 1.9 cubic feet per second per square mile, or sufficient to cover every acre within the State to a depth of nearly 2 feet per year. The greater part of this run-off occurs in the western part of the State, where it is impossible to utilize even the larger portion of it for irrigation purposes.

The possibilities for water-power development in this section are apparently almost unlimited. In the eastern part of the State, however, only such water as escapes into deep canyons, like those of the lower Deschutes or the John Day rivers, will eventually be permitted to escape without serving the State in the irrigation of arid land. Even that which thus escapes will be put to use turning water wheels for the generation of electricity.

For convenience in discussing the subject of water resources, the State will be divided into drainage districts and the peculiarities of these districts noted. Owing to the peculiar topographic conditions, 5 divisions are necessary, as follows:

(1) The Willamette drainage, consisting of all that region between the Cascade and Coast Range mountains drained by the Willamette River.

(2) The Columbia River drainage, or that part of eastern Oregon between the Cascade Range and the Blue Mountains which drains into the Columbia. The principal streams in this division are Deschutes, John Day, Umatilla, and Walla Walla rivers.

(3) Snake River drainage, or that portion of the State east of the Blue Mountains which drains into the Snake River, the principal streams being the Grande Ronde, Powder, Burnt, Malheur, and Owyhee rivers.

(4) The Great Basin, or the high plateau region of central Oregon, which has no apparent outlet.

(5) The Coast drainage, or streams in western Oregon which flow directly into the Pacific Ocean. The principal streams of this district are the Nehalem, Siletz, Umpqua, Rogue, and Klamath rivers.

To illustrate graphically the behavior of streams in these various drainage districts, three hydrographs, or charts, have been prepared, which show the daily fluctuations of typical streams in the Willamette, the Columbia, and the Snake river drainages. Figure 2 (p. 10) shows on an exaggerated scale a cross section of the State cutting the drainage basins of the three streams which have been thus selected and the relative steepness of the different watersheds.

Figure 4 shows graphically the daily fluctuations in the drainage of the McKenzie River, as measured near Eugene during 1906. This starts at the summit of the Cascade Mountains, being fed during the summer by the melting of the perpetual snows of the Three Sisters Mountains. It falls, as shown by figure 2 (p. 10), from an average elevation of about 6,000 feet at the base of these mountains to an elevation of 450 feet at Eugene, a distance of about 70 miles. This catchment area is quite steep, is heavily timbered with a dense growth of tall fir, at the base of which is a heavy growth of brush, tangled logs, and decaying vegetation. The timber has been removed from only a very limited portion of this drainage area, near the mouth of

the stream. Very rapid changes in daily discharge, with extreme floods during November, December, January, and February, will be noted. The highest flood in 1906 occurred in November, lasting for several days and reaching the enormous discharge of 17,400 cubic feet per second. The diagram extends only to a discharge of 14,000 cubic feet per second. A constant flow of approximately 2,260 cubic feet per second occurs during the summer months. The lowest run-off is shown during the latter part of September and early October, reaching a minimum of 1,630 cubic feet per second.

The daily discharge and fluctuations of the West Fork of the Deschutes River at Lava during 1906 is shown by figure 5. At this point

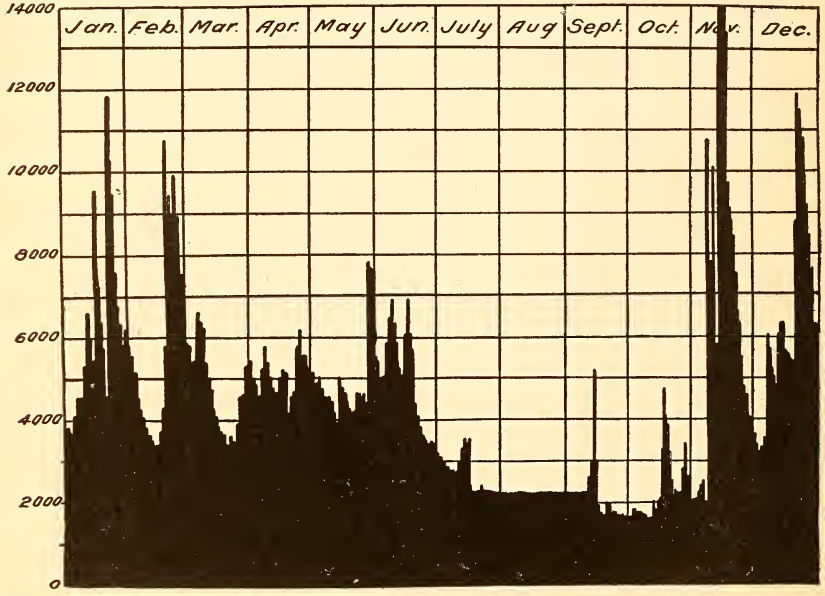


FIG. 4.—Hydrograph showing daily discharge in cubic feet per second of the McKenzie River near Eugene during 1906.

the water which flows from the east slope of the Cascade Mountains directly opposite the McKenzie River watershed is measured. This slope, as indicated in figure 2 (p. 10) is small, as compared with that of the McKenzie. The watershed is covered with the usual heavy growth of yellow pine, is without underbrush, and is typical of the east slope of this range. The soil is very porous, being composed of light volcanic ash intermixed with pumice stone. It contains but little humus and supports a good growth of bunch grass. It will be observed that no floods occur on this stream. The average flow for 1906 was 882 cubic feet per second. This hydrograph is in general typical of the flow from the east slope of the Cascades, but not of the entire Columbia River drainage.

The daily discharge in cubic feet per second of the Malheur River at Vale during 1906 is shown in figure 6. It is typical of most streams in the arid portion of the State. This stream drains the east slope of the cross section of the State as shown in figure 2 (p. 10). Its water-

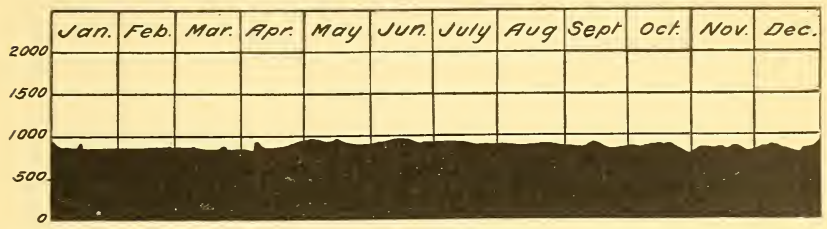


FIG. 5.—Hydrograph showing daily discharge in cubic feet per second of the west fork of Deschutes River at Lava during 1906.

shed is comparatively steep, overgrazed, and barren, except in the high mountains, where some timber occurs. The soil contains but little humus and is comparatively firm. Practically no run-off is shown except in March, April, and May, when the spring thaw occurs and

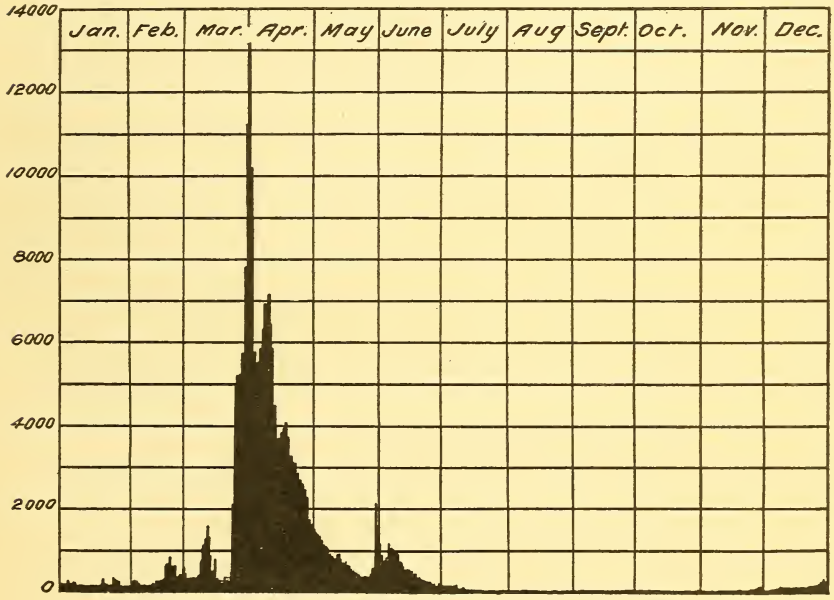


FIG. 6.—Hydrograph showing daily discharge in cubic feet per second of Malheur River at Vale during 1906.

the snow melts rapidly in the mountains. The average flow available for irrigation purposes during May and June, as shown, will not exceed 500 cubic feet per second. This supply falls off rapidly to July 1, and reaches a minimum of 4 cubic feet per second soon after that date.

Many feasible reservoir sites exist along the Malheur River and most other streams in the arid district. One of these, which has been fully investigated by the Government, will retain, by the construction of a 140-foot dam, every drop of water discharged by this stream in two average years. The area which will ultimately be reclaimed through storage, under favorable legislation, will be as much greater than the present area as the average flow of the river is greater than the July flow, as shown in figure 6 (p. 15).

The following tables give more in detail the behavior of streams in each of the five drainage districts mentioned above. The information has been compiled from the Water Supply Papers published by the Hydrographic Division of the U. S. Geological Survey, and for more detailed study these publications should be consulted. For each stream where discharge measurements are published for a series of years, the results of the most typical year only have been summarized. The maximum and minimum discharges reported give an idea of the extreme range of fluctuation. The mean discharge during August gives a general idea as to the ordinary flow of the stream at the time irrigation is most necessary. The minimum flow for the year may or may not occur during this month. One cubic foot per second, in general, irrigates 70 to 100 acres of land. The column headed total discharge in acre-feet will convey an idea as to the total area which can be reclaimed, if the total annual flow can be conserved by storage. In general, it will take from 3 to 4 acre-feet of stored water to reclaim 1 acre of land, depending on the amount lost by seepage and evaporation in transporting the water to the place of use. One cubic foot per second flowing twenty-four hours equals 2 acre-feet, or will cover 1 acre to a uniform depth of 2 feet. The column headed run-off in cubic feet per second per square mile is given to convey an idea as to the amount of stream flow which can be expected per square mile of watershed in the different parts of the State. If accurate stream measurements are not available for any given point, the approximate run-off can be estimated by computing from some reliable map the drainage area above the proposed point of diversion, and multiplying this area by the run-off in cubic feet per second per square mile reported for some stream in that vicinity where similar conditions as to rainfall, slope, forest covering, etc., occur. The average daily discharge in cubic feet per second to be expected in computing the quantity of water available for storage can be secured by multiplying the drainage area in square miles by the figures given under the column headed annual, and the flow expected during August by the figures in the last column.

Discharge of streams in Oregon.

WILLAMETTE VALLEY DRAINAGE.

Name of stream and place of measurement.	Typical year.	Discharge.				Run-off per square mile.	
		Maximum.	Minimum.	Mean during August.	Total.	Annual.	During August.
		Cu. ft. per sec.	*Cu. ft. per sec.*	*Cu. ft. per sec.*	*Acre-ft.*	*Cu. ft. per sec.*	*Cu. ft. per sec.*
Willamette River at Albany	1906	52,800	2,810	3,680	9,060,000	2.59	0.76
Middle Fork Willamette River at Jasper	1906	16,400	800	969	2,900,000	2.77	.67
Coast Fork Willamette River at Goshen	1906	15,000	68	108	1,130,000	2.28	.16
McKenzie River near Springfield	1906	17,400	1,630	2,260	3,350,000	4.84	2.35
North Fork Santiam at Mehama	1906	36,200	700	809	2,830,000	5.31	1.09
South Fork Santiam at Waterloo	1906	36,900	192	298	2,520,000	5.48	.47
Luckiamute River near Suver	1906	7,450	37	85	784,000	.....	.....
Molalla River near Molalla	1906	7,120	60	77.6	656,000	4.15	.35
Yamhill River at Sheridan	[a] 1906	2,200	38	81	125,000	.....	.....
Clackamas River	1906	25,100	818	890	2,690,000	4.66	1.11

COLUMBIA RIVER DRAINAGE.

Hood River at Winans	1906	6,580	490	674	891,000	3.33	1.82
Deschutes Basin:							
Deschutes River at Moro	1899	15,480	5,100	6,628	5,972,952	.83	.67
Deschutes River at Lava	1906	559	89	122	145,000	.23	.14
East Fork Deschutes River at Odell	1906	174	29	37.8	52,300	.52	.20
West Fork Deschutes River near Lava	1906	985	777	883	638,000	2.45	2.45
Deschutes River at West's ranch	[b] 1906	1,510	1,290	1,410	448,000	1.12	1.14
Tumalo Creek near Laidlaw	[c] 1906	450	88	82.6	47,200	1.60	.92
Squaw Creek near Sisters	[d] 1906	458	67	133	34,800	1.56	1.48
Central Oregon Canal near Bend	1906	138	0	.....	55,600	.....	.....
Pilot Butte Canal near Bend	1906	181	0	.....	54,800	.....	.....
Columbia Southern Canal near Laidlaw	[d] 1906	114	55	.....	23,400	.....	.....
Crooked River at Forest	[e] 1906	3,940	75	.....	.....	.....	.....
John Day Basin: John Day River at McDonald	1906	13,800	162	236	1,480,000	2.62	.03
Umatilla Basin:							
Umatilla River at Gibbon	1901	4,155	88	98	474,630	1.90	.28
Umatilla River at Yoakum	1906	23,900	28	39.4	602,000	.69	.03
Umatilla River at Umatilla	1906	15,200	0	.09	505,000	.33	0
Willow Creek Basin: Willow Creek near Arlington	[f] 1906	1,640	10	.....	32,100	.....	.....
Walla Walla Basin:							
Walla Walla River near Milton	1904	2,220	120	136	241,000	.....	.....
South Fork Walla Walla River near Milton	1904	1,655	90	177	169,500	.....	.....

[a] From April 25 to September 30.
[b] From July 21 to December 31.
[c] From May 15 to October 31.
[d] From July 1 to October 31.
[e] Results of five discharge measurements made between January 9 and October 14.
[f] From March 1 to July 21.

Discharge of streams in Oregon—Continued.

SNAKE RIVER DRAINAGE.

Name of stream and place of measurement.	Typical year.	Discharge.				Run-off per square mile.	
		Maximum.	Minimum.	Mean during August.	Total.	Annual.	During August.
Grande Ronde Basin:		*Cu. ft. per sec.*	*Cu. ft. per sec.*	*Cu. ft. per sec.*	*Acre-ft.*	*Cu. ft. per sec.*	*Cu. ft. per sec.*
Grande Ronde River at Elgin	1906	5,200	45	47.8	603,000	0.65	0.04
Wallowa River near Joseph	1906	561	26	208	102,000	2.99	4.43
Wallowa River near Wallowa	1906	3,100	170	255	397,000	1.08	.50
Wallowa River near Elgin	1906	5,420	300	384	530,000	1.18	.44
Powder River Basin: Powder River at Salisbury	1906	810	5	11.1	80,400	.40	.04
Burnt River Basin: Burnt River at Huntington	[a] 1905	393	.....	.....	.....	.....	.....
Malheur River Basin:							
Malheur River near Vale	1906	12,800	4	8.6	527,000	.15	.002
Bully Creek above Vale	1906	2,640	3	3	57,200	.12	.005
Willow Creek near Malheur City	[b] 1906	402	.....	.....	18,600	.....	.....
Owyhee River near Owyhee	1906	11,600	17	21	1,040,000	.12	.002

GREAT BASIN DRAINAGE.

Harney Valley:							
Silvies River near Burns	1904	4,730	6	21.9	301,600	.....	.....
Silver Creek near Riley	[c] 1906	581	17	.....	46,900	.....	.....
Abert Lake Basin: Chewaucan River at Paisley	1906	1,000	23	30.4	137,000	0.69	0.11
Summer Lake Basin: Ana River near Summer Lake	1905	149	148	.....	108,405	.....	.....
Silver Lake Basin:							
Silver Creek near Silver Lake	1906	530	5	12.8	39,800	.25	.06
Bridge Creek near Silver Lake	[d] 1906	29	4	.....	6,250	.....	.....
Bear Creek near Silver Lake	[e] 1906	65	27	.....	.....	.....	.....

PACIFIC COAST DRAINAGE.

Siletz River near Siletz	[f] 1906	4,310	130	199	480,000	4.78	0.87
North Fork Umpqua River at Oak Creek	1906	26,800	952	1,090	2,830,000	3.93	1.09
Nehalem River at Fishawk	[g] 1906	386	102	.....	.....	.....	.....
South Fork Umpqua River at Brockway	1906	46,400	171	200	1,700,000	1.50	.11
Rogue River at Tolo	1906	27,800	1,230	1,390	2,120,000	1.46	.69
Link River at Klamath Falls	1906	4,440	1,150	1,470	1,630,000	.....	.....
Klamath River at Keno	1906	3,960	1,240	1,680	1,690,000	.....	.....
Lost River near Clear Lake, Cal	1906	1,780	5	8	153,000	.....	.....
Lost River near Merrill	1906	4,380	66	94	186,400	.....	.....
Miller Creek near Lorella	1906	2,360	.....	.....	85,500	.....	.....
Sycan River near Silver Lake	[h] 1906	192	.....	3	16,200	.....	.....

[a] Records of four measurements made between March 3 and November 22.
[b] From May 23 to August 14.
[c] From February 1 to July 14.
[d] From January 1 to July 21.
[e] Records of three discharge measurements made between April 9 and June 27.
[f] From March 1 to November 7.
[g] Records of four measurements made between April 18 and August 1.
[h] From May 1 to October 1.

It will be observed from the foregoing tables that in the Willamette River drainage those streams which head in the high Cascade Mountains yield an annual run-off of from 4.1 to 5.5 cubic feet per second per square mile, while typical streams in the Great Basin or desert region produce only 0.25 to 0.69 cubic foot per second per square mile. In the Columbia River drainage considerable variation in the run-off per square mile will be noticed. This is caused by the fact that measurements made at the mouth of such a stream as the Deschutes include the drainage, not only of the east slope of the Cascades but of much larger territory of comparatively arid land to the east. The summer flow of the Willamette River is more than sufficient to irrigate the entire valley, for the duty of water would be high as compared to the more porous lands in the eastern part of the State. The low-water flow of the stream occurs after the short period when irrigation is necessary, and the return seepage water would probably greatly benefit navigation or power development in the lower part of the stream. The low-water flow at Oregon City has been estimated by the U. S. Army engineers at 5,000 cubic feet per second. The low-water flow of the Columbia River at The Dalles is reported to be 50,000 cubic feet per second.

WATER POWER.

The most important streams in the State for the development of water power are those heading in the high, perpetually snow-clad Cascade Mountains and dropping rapidly to the sea level. Of these streams the Deschutes River, having a minimum flow of 5,100 cubic feet per second, and flowing through a narrow canyon in solid rock for 90 miles above its mouth, is the most important. This stream parallels the Willamette Valley and flows into the Columbia River 90 miles east of Portland. It has 3,480 feet fall from Bend to its mouth, 500 feet of this being in the last 36 miles. Within this distance of 36 miles 290,000 theoretical horsepower can be developed.[a] This, at the extremely low value of $10 per horsepower per year, would produce an annual revenue of nearly $3,000,000.

Hood River falls 740 feet in the last 11 miles of its course. It will furnish 2,800 brake-horsepower per mile.

The McKenzie River has an average low-water flow of about 2,200 cubic feet per second. Its fall is 11.5 feet per mile in the vicinity of Eugene and 26 feet per mile at Belknap Bridge. In the 39 miles above Hendricks Ferry its fall averages 16.7 per mile.

[a] One cubic foot per second of water falling 8.8 feet will produce one theoretical horsepower.

The North Fork of the Santiam River has a minimum flow of 727 cubic feet per second at Mehama. It falls 14.9 feet per mile in the vicinity of Mill City and 66.3 feet per mile near Idanha, 24 miles above. The average in this region is 37.5 feet per mile.

Fifteen thousand electric horsepower is now being developed at Cazadero, on the Clackamas River, and about 12,000 horsepower at Oregon City during low water in the Willamette. At Gold Ray, in southern Oregon, on the Walla Walla River, and at Rock Creek, in eastern Oregon, large hydro-electric power plants are in operation. A large plant is being constructed near Portland, on the Sandy River.

The total possible water power of the State has not been closely estimated as yet, because of the lack of water-supply data and profile elevations of streams. However, it certainly is far in excess of the needs of the immediate future.

LANDS.

On July 1, 1906, nearly one-third of the State's area was vacant, unreserved public land subject to entry under the public-land laws of the United States. The distribution of this land and its general character are shown in the following table, taken from the report of the Secretary of the Interior for the year ended June 30, 1906:

Unappropriated public lands in Oregon July 1, 1906.[a]

Land district and county.	Area unappropriated and unreserved.			Brief description of character of unappropriated and unreserved land.
	Surveyed.	Unsurveyed.	Total.	
Burns:	*Acres.*	*Acres.*	*Acres.*	
Baker	154,840	.....	154,840	Principally grazing; some timber.
Crook	101,400	.....	101,400	Do.
Grant	263,096	2,880	265,976	Grazing, timber, farming.
Harney	3,208,644	1,549,755	4,758,399	Do.
Malheur	3,144,942	2,232,684	5,377,626	Do.
Wheeler	29,610	.....	29,610	Do.
Total	6,902,532	3,785,319	10,687,851	
Lagrande:				
Baker	705,598	18,112	723,710	55 per cent timbered mountains, 10 per cent arid, 25 per cent grazing, 10 per cent farming.
Grant	337,290	20,363	357,653	50 per cent timbered mountains, 35 per cent grazing, 15 per cent farming.
Morrow	18,233	.....	18,233	25 per cent timbered mountains, 40 per cent grazing, 25 per cent arid, 10 per cent farming.
Umatilla	108,245	539	108,784	30 per cent timbered mountains, 30 per cent arid, 35 per cent grazing, 5 per cent farming.
Union	9,723	18,358	28,081	75 per cent timbered mountains, 15 per cent grazing, 10 per cent farming.
Wallowa	317,333	263,674	581,007	50 per cent timbered mountains, 45 per cent grazing, 5 per cent farming.
Total	1,496,422	321,046	1,817,468	

[a] Report of U. S. General Land Office, 1906.

Unappropriated public lands in Oregon July 1, 1906—Continued.

Land district and county.	Area unappropriated and unreserved.			Brief description of character of unappropriated and unreserved land.
	Surveyed.	Unsurveyed.	Total.	
Lakeview:	*Acres.*	*Acres.*	*Acres.*	
Cook	370,135		370,135	One-tenth mountains, two-tenths agricultural, seven-tenths grazing.
Klamath	185,641	100,000	285,641	Two-tenths timber three-tenths agricultural, five-tenths grazing.
Lake	1,772,786	682,505	2,455,291	Three-tenths timber, one-tenth mountainous, three-tenths agricultural, three-tenths grazing.
Total	2,328,562	782,505	3,111,067	
Portland:				
Benton	8,510	440	8,950	Broken grazing lands.
Clackamas	42,434	37	42,471	Timbered, farming, and grazing lands.
Clatsop	15,072	4,920	19,992	Timbered and grazing lands.
Columbia	2,206		2,206	Rolling and broken timber lands.
Lincoln	98,822	68,276	167,098	Timber and grazing lands, broken.
Linn	10,333	17,000	27,333	Timber and grazing lands.
Marion	6,855		6,855	Farming and timber lands, broken.
Multnomah	1,014		1,014	Timber lands.
Polk	1,216	5,640	6,856	Broken timber, and grazing lands.
Tillamook	87,357	3,680	91,037	Timber and grazing lands, broken.
Washington	3,469		3,469	Rolling timber, and grazing lands.
Yamhill	34,452		34,452	Do.
Total	311,740	99,993	411,733	
Roseburg:				
Benton	2,407		2,407	Timber and grazing lands.
Coos	45,346	62,377	107,723	Timber, agricultural.
Curry	157,337	59,683	217,020	Mountainous timber.
Douglas	104,910	52,644	157,554	Mineral, grazing, and agricultural.
Jackson	220,741	77,275	298,016	Timber, grazing, fruit.
Josephine	78,506	15,739	94,245	Fruit, farming, and mining.
Klamath	5,910	27,253	33,163	Timber.
Lane	254,603	75,517	330,120	Timber, farming, and mining.
Lincoln	44,565	6,019	50,584	Broken, grazing.
Linn	13,967	42,656	56,623	Hilly, grazing.
Total	928,292	419,163	1,347,455	
The Dalles:				
Crook	1,146,867	125,467	1,272,334	Lands in district are broken and hilly, and principally adapted to grazing purposes. There are some small valleys and some undulating table-lands which constitute good farming lands. Greater portion is broken, hilly, and mountainous.
Gilliam	176,288	28,741	204,969	
Grant	58,699		58,699	
Morrow	82,339		82,339	
Sherman	988		988	
Wasco	139,993	105,751	245,744	
Wheeler	498,802	200	499,002	
Total	2,103,916	260,159	2,364,075	
State total	14,071,464	5,668,185	19,739,649	

The greater part of the vacant land is a long distance from present railway transportation and is suitable mainly for grazing. With better transportation facilities much of it can be utilized for dry farming, or be reclaimed through the storage of winter flood waters. Home seekers desiring to enter such lands should apply to the General Land Office, Washington, D. C., or to any of the local land offices mentioned in the foregoing table for the necessary instructions.

On January 1, 1908, the State had 532,710 acres of unsold school lands. These are being sold at the present time for $5 per acre. Settlement is not required as a condition of purchase. Detailed information can be secured upon application to the State land board, Salem, Oreg.

Oregon had contributed $5,260,450 to the United States reclamation fund up to June 30, 1906, and the Reclamation Service estimates that on December 31, 1911, when this fund should be equalized among the various States, over $9,000,000 will have been contributed. Two projects, one in Klamath County and the other in Umatilla County, are now under construction. These will cost ultimately about $4,000,000, and will irrigate 165,000 acres. Detailed information as to the manner of securing land and water rights under these projects can be secured by addressing the U. S. Reclamation Service, Washington, D. C.

The State has selected 432,203 acres of land for reclamation under the provisions of the Carey Act. During 1907 the State let three contracts involving the reclamation of 183,834 acres of this land, at a cost to future settlers of $4,692,700, or an average price of about $25 per acre. Actual settlement is required as a condition for purchase of these lands. The rules of the State concerning settlement and cultivation can be secured by addressing the Desert Land Board, Salem, Oreg.

A total of 16,463,535 acres of valuable timber land was included in National Forests within the State on April 1, 1907. It is estimated that the woodlands of Oregon cover 54,300 square miles, or about 57 per cent of the total area of the State. Of this area about one-half is included in the National Forests, created prior to April 1, 1907. The total stand of timber in the State was reported in the Twelfth Census to be 225,000,000,000 feet, of which 150,000,000,000 feet was red fir, 40,000,000,000 feet was yellow pine, and the remainder mainly cedar, hemlock, and spruce. Near the Pacific coast, in the northern part of the State, stands of 100,000 feet board measure per acre have been reported for entire townships. The timber on the National Forests can be secured free, in limited amounts, by actual home builders in the vicinity of the reserves. The mature timber is sold for commercial purposes to the highest bidder. Each settler is permitted to turn a certain amount of stock onto the grazing lands within these reserves free of charge, but large companies are charged a small amount per head turned in, and the total number is limited to prevent overgrazing and denuding of the forest range. Where open tracts more suitable for agricultural purposes than for forest purposes are found within the National Forests, they will be thrown open to entry upon application to the Forest Service under the general

land laws. Special permission must be secured before occupying land within National Forests for canal rights of way, reservoir sites, power-house sites, etc., and certain charges are made for these privileges. Those interested can secure detailed information by addressing the Forest Service, Washington, D. C., and asking for the small book "The Use of the National Forests."

Under the larger ditch systems in the eastern part of the State considerable uncultivated land with partial or full water rights can be found for sale at prices ranging from $50 to $150 per acre. Unirrigated wheat lands along the Columbia River range in price from $25 to $75 per acre, while in the vicinity of Athena sales at $100 per acre are reported. In the Willamette Valley the most fertile lands, partially improved, can be purchased for $30 to $60 per acre. This land, supplied with a small amount of water through pumping from wells or by gravity flow, will make possible intensive farming and be worth from $100 to $300 or more per acre. Large areas of logged-off or stump lands in western Oregon are available for settlement at low prices.

The low-water flow of nearly all the streams in western and southern Oregon has been fully appropriated, but the total area which these streams are capable of supplying, as indicated by the above summary of water resources, is many times that already reclaimed. In order to accomplish this result, however, many engineering difficulties must be overcome.

From the foregoing table, page 20, a general idea of the character of the vacant public land in the different counties of the State can be gained. It is impossible to state from the information at hand what percentage of those lands can ultimately be reclaimed.

As shown by the table of irrigation enterprises for Umatilla County, page 42, there are approximately 30,000 acres of land under already constructed ditch systems in private ownership open to settlement along the Umatilla River. The largest single tract is under what is known as the Furnish ditch. The construction of this ditch has been completed but recently. It supplies flood waters to about 10,000 acres of sagebrush land adjoining and above the Government project which is nearing completion at Hermiston. The next largest tract is that located under the Hinkle ditch, on the Umatilla River, opposite Echo. The total acreage is not known, but the canal has been estimated to carry a flow of 250 cubic feet per second of water, and in 1905 was irrigating only 800 acres. A tract of considerable proportions which is being developed near Irrigon is, perhaps, the next in area.

According to the following estimate by C. C. Hutchinson, made in 1906, there is in the lower Malheur and Owyhee valleys 30,000 acres

of undeveloped land under the important ditches built by private enterprises. This is distributed as follows:

Acreage under Malheur County canals.

Name.	Year built.	Acres irrigated.	Additional capacity, acres.
Owyhee ditch	1886	8,000	12,000
Nevada ditch	1882	4,000	2,000
Mill ditch, at Vale	1901	1,000	4,000
Sand Hollow ditch	1886	1,000	1,000
Gillerman ditch	1883	3,000	.....
Farmers Ditch Company	1885	3,000	.....
Linebarger ditch	1887	500	.....
Ricker ditch	1885	1,500	3,000
McLaughlin ditch	1883	1,800	2,000
Wilson ditch	1894	600	5,400
Vines ditch	1894	300	1,000
Lower Willow Creek ditches	1862	20,000	.....
Total	.....	44,700	30,400

In Baker county the only important irrigation development under way is that of the Baker Irrigation Company, which has nearly completed the necessary storage facilities for the irrigation of 10,000 acres in the vicinity of Baker City.

Under the provisions of the Carey Act plans have been completed for the reclamation by the State of approximately 225,000 acres of land in Crook County. The main canals for about 80,000 acres of this have been completed. The Deschutes Irrigation and Power Company, at Bend, has already sold 40,591 acres, and 17,552 acres have recently been approved for sale at $40 per acre for the irrigable lands. The entire tract will doubtless be under irrigation within a few years.

The U. S. Reclamation Service has practically completed the construction of a storage project for the reclamation of 20,000 acres at Hermiston, in Umatilla County. In August, 1908, its plans were 33 per cent completed for the reclamation of 183,000 acres in Klamath County, known as the Klamath project.

It is estimated that within the next few years there will be opened for settlement under existing canals and those now under construction a total of 380,000 acres of irrigable land providing homes for 9,500 families.

Area of irrigated land in Oregon subject to settlement within the near future.

	Acres.
Area under private canals, estimated	80,000
Area under State Carey-Act projects, undisposed of	180,000
Area under government projects, public lands or excess holdings, estimated	120,000
Total	380,000

PRODUCTS OF IRRIGATED LANDS.

The great variety and excellent quality of products which can be grown in Oregon is, perhaps, the leading feature in the agricultural development of the State. While the northern part of the State is in the same latitude as Montreal, Canada, the climate is so mild that many semitropical products are successfully grown. This mildness of climate, as compared with that of the same latitude on the Atlantic coast, is due to the warm Japan current. In the coast cities palm trees have stood, unprotected, the test of many winters and look as thrifty as those in southern California; hundreds of acres of English walnuts are being planted in the Willamette Valley, and almonds are successfully grown at Umatilla in the northern part of the State. The usual outdoor work can be carried on as well during the winter as during the summer, there being but few days when the temperature is so low as to make it uncomfortable. There is no long period of idleness awaiting the melting of snow. In nearly all the agricultural sections of the State, including the high plateaus of central Oregon, the snow usually melts as soon as it reaches the ground. Occasionally snow a few inches deep remains for several days and during exceptional years snow may remain for two or three weeks.

The markets for the irrigated products are as varied as the products. In central Oregon hay and grain are produced only in sufficient quantities to carry the stock of that section through the winter months. Little else is produced because of the limited local market. Along Malheur, Umatilla, and Crooked rivers and other streams, which have tributary to them extensive areas of grazing land, alfalfa is the leading irrigated product. Stock from the range is driven to these sections for winter feed. The greater the area of alfalfa the greater seems the demand.

Owing to the excellent keeping qualities of the fruit produced in the vicinity of railway transportation, it is shipped to all parts of the world. Oregon apples net the grower $2.50 per bushel, with $1 per bushel for culls, and are shipped to New York, London, Siberia, and China. One lot of Oregon Newtons sent to Edinburgh, Scotland, sold for $4.83 per box. Willamette Valley cherries have been expressed to Montana with profit for many years without loss from decay in transit. The local mining districts consume large quantities of irrigated products.

The products of eastern and southern Oregon reach the markets several weeks in advance of those from the Willamette Valley. This is due to the absence of clouds and better growing weather during the spring in these sections.

Irrigation is necessary for the highest development of dairying in all parts of the State. Owing to the favorable conditions which

exist and the cheapness of production, Oregon's dairy products can compete successfully with those of other States. The market, therefore, is unlimited. During 1906 the average price of first-class butter in the Portland market was 32.23 cents per pound, and the average price paid for butter fat by the local creameries was 30.72 cents. Prof. G. L. McKay, dairy instructor of Ames, Iowa, who was sent by the U. S. Department of Agriculture to study dairy conditions in Europe, and who spent some time in the dairy countries of Holland, Denmark, Sweden, and the Jersey Isles, said: "In my judgment there is no place in the world where dairy products can be produced as cheaply as in Oregon."

The State Dairy and Food Commissioner's report for 1907 gives a list of 350 creameries, with their exact location, also 77 cheese factories. The total value of the dairy products of Oregon during 1907 was $17,000,000. The output of condensed milk from Washington County has a value of about $1,500,000 annually. The commissioner says:

> Western Oregon is preeminently suited to dairying. Perhaps no country in the world is better suited. This is not our boast alone, but it is the expressed opinion of all great dairy authorities who have examined into conditions here.

In regard to the returns from fruit growing in Oregon, the secretary of the State Board of Horticulture says:

> The total value of the products of the average farm in the United States, as shown by the Twelfth Census, is $826 per year. There is ample evidence that crops of fruit exceeding in value $1,000 per acre have been gathered and marketed in Oregon, and there is no reason to suppose the days of such returns are over.
>
> The fruits which are best adapted for general planting on fruit farms of small size in Oregon should give average yields and cash returns per acre as follows:

Average yields and values of fruits grown in Oregon.

Kind of fruit.	Yield per acre.	Cash returns per acre.	Kind of fruit.	Yield per acre.	Cash returns per acre.
Apples.....bushels..	300	$200–350	Black-cap raspberries, ...pounds..	4,000	$160–240
Pears.....tons..	8	120–320	Red raspberries.....do....	5,000	150–270
Cherries.....pounds..	5,000	150–350	Loganberries.....do....	8,000	180–320
Strawberries.....do....	4,000	120–240	Filberts.....do....	2,400	200–240

The foregoing figures show that there is no difficulty in making a selection of fruits for a farm of 10 acres which would give average returns of from $1,500 to $2,000.

To give an idea as to the output and commercial value of different products, under good farming, the following table, showing the kind of crop raised, the size of the field reported, the total yields,

and the net profits per acre, has been prepared from data gathered from reliable sources in the several districts:

Yield and net profits per acre of crops grown in Oregon.

Kind of crop.	Size of field.	Total yield.	Net profit per acre.
	Acres.		
Eastern Oregon: Alfalfa		3 crops	
Northern Oregon:			
Alfalfa		3 crops	$32.00
Sugar beets			40.00
Prunes	16		140.00
Apples	2 9	2,329 boxes	[a] 1,470.00
Do	15	5,000 boxes	567.00
Do	3 3	1,141 boxes	598.50
Do	20		[b] 750–900.00
Pears	7	$15,400	
Do	30		1,068.00
Mixed fruit trees	1.33		900.00
Mixed trees and berries	6 25	$3,400	240.00
Strawberries	12		[b] 150–350.00
Do	10		[c] 250.00
Willamette Valley:			
Alfalfa		4 crops	[d]
Prunes	12	40,000 pounds	93.00
Potatoes	1	300 bushels	
Clover seed	1	$50	
Berries	1	$334	
Onions	2	120,000 pounds	
Cabbage	2 5	35,000 pounds	

[a] Gross income, not net profit.
[b] Average for several years.
[c] Crop raised between immatured fruit trees.
[d] No irrigation.

High-grade Jersey heifers, 1½ years old, sell readily for $50 per head in the Willamette Valley, and the annual income from registered long-wool ewes of all breeds is $20 each. Tokay grapes have been raised in southern Oregon that outsold the California-grown Tokay grapes 15 cents per crate in the Portland market.

The alfalfa reported for the Willamette Valley was grown at the State Experiment Station at Corvallis without irrigation. The crops were, respectively, 16, 6, 3, and 3 tons of green feed, besides fall pasture. This is equivalent to 9⅓ tons of dry matter. Dr. James Withycombe, director of the station, estimates that with irrigation the yield can be increased to 12 tons of dry matter.

The county fruit inspectors of Marion County, in the Willamette Valley, reported, in 1907, 124 owners of prune driers, and the total cured product as 6,500,000 pounds for that county alone.

Land in the northern part of the State, near Hood River, can be purchased for $30 to $150. Bearing orchards in this section are valued at $500 to $1,500 per acre.

HISTORY OF IRRIGATION DEVELOPMENT IN OREGON.

Irrigation in Oregon may be said to antedate the advent of the white man, as much of the land classed as under irrigation at the present time is that which produces a crop of wild hay after the sub-

sidence of the natural spring overflow of the streams. The earliest irrigation development occurred when the area thus irrigated was extended by the construction of temporary dams and dikes, forcing the flood water over a greater area. As nearly as can be estimated, about 56 per cent of the land classed as irrigated in Oregon at the present time is of this character. Later, ditches were constructed to not only lead the flood waters over a greater area, but to divert the low-water flow of the streams. On many of the streams of eastern Oregon the low-water summer flow is entirely consumed. The seepage water returns to the stream only to be rediverted. Umatilla River, for example, at the present time is dry during the summer time at three different points.

The first irrigation by the construction of canals probably occurred along the Walla Walla River about sixty years ago. The diversion of water was comparatively inexpensive, as the bed of the stream in the lower valley was higher than the adjoining lands. Even at the present time, no comprehensive system has been established for more economically dividing the stream among those having rights to its use, and no permanent structures or diversion works have been installed. This valley has been highly developed through irrigation, but further progress was impossible until the enactment of the irrigation law by the 1909 legislature, for the summer flow had been fully appropriated, and it was not possible under previous laws to store the winter flow of this stream in the mountains and convey it past the 199 ditch diversions to the unimproved lands of the lower valley. Many other valleys where the irrigated area is limited by the summer flow of the stream have developed in a manner similar to the Walla Walla.

In the Malheur Valley irrigation development has been under way for thirty years and some ditches of a permanent nature are in operation. In Harney County irrigation development is in its first stage, about 90 per cent of the 80,000 acres irrigated being watered by the natural overflow of streams aided by primitive diversion works.

Not until 1890 did irrigation begin to be regarded as a pertinent factor in the future development of the State. The introductory stage of irrigation in Jackson, Josephine, and Douglas counties, in southwestern Oregon, has been passed long since, and it is now regarded as necessary to proper cultivation. Irrigation is gradually creeping northward as the benefits to be derived from it are impressed upon the people. However, even to-day its great importance is not comprehended by the inhabitants of the semihumid Willamette Valley, many of whom persistently deny that any such method of agriculture will ever be necessary where the annual rainfall is 40 inches. While wonderful results can be secured without irrigation, it

must be remembered that less than 6 per cent of the total rainfall occurs during the summer months, or best growing period of the year.

According to Bulletin No. 16 of the U. S. Census Bureau, the total irrigated area within the State of Oregon in 1902 was 439,981 acres and the irrigation system for this cost $2,089,609, showing the great opportunity for development here.

In the following table, taken from the report of the Twelfth Census, are given the areas of irrigated land in the different counties and the number of irrigators in 1889 and 1899, together with the percentage of increase or decrease during the decade:

Number of irrigators and areas irrigated in 1889 and 1899, with per cent of increase.

Counties.	Number of irrigators.			Number of acres irrigated.		
	1899.	1889.	Per cent increase.	1899.	1889.	Per cent increase.
Baker	594	408	45.6	46,754	31,471	48.6
Crook [a]	212	245	17.9	13,921	8,618	39.7
Gilliam [a]	32	78		1,086	1,037	
Grant [a]	327	325		19,632	18,718	
Wheeler [a]	193	.....		4,998	.....	
Harney	228	240	[b] 5.0	111,090	26,289	322.6
Jackson	409	169	142.0	7,054	3,230	118.4
Josephine	235	144	63.2	4,121	2,598	58.6
Klamath	129	56	130.4	23,911	5,699	319.6
Lake	272	355	[b] 23.4	51,995	25,549	103.5
Malheur	479	329	45.6	49,295	22,037	123.7
Morrow	76	45	68.9	3,865	879	339.7
Sherman	12	8	50.0	112	142	[b] 21.1
Umatilla	329	148	122.3	5,168	3,571	44.7
Union	494	346	42.8	26,735	21,947	21.8
Wallowa	178	111	60.4	14,016	4,147	238.0
Wasco	303	143	111.9	3,342	2,012	66.1
Total [c]	4,502	3,150	42.9	387,095	177,944	117.5

[a] Wheeler County formed in 1899 from parts of three above counties.
[b] Decrease.
[c] Includes only 17 principal irrigated counties. In all others there were, in 1899, 134 irrigators, and an irrigated area of 1,215 acres.

The irrigated area of Harney County increased 322.6 per cent between these periods, while the total number of irrigators decreased 5 per cent. This can be accounted for by the great areas along Silvies and Blitzen rivers in the vicinity of Malheur Lake, which were put under flood-water irrigation by the large cattle companies which probably bought out some of the early irrigators. Lake County shows a decrease of 23.4 per cent in the number of irrigators, with an increase of 103.5 per cent in the irrigated areas. This remarkable condition is accounted for by the reclamation and irrigation by large cattle companies of Chewaucan, Sycan, and Paulina marshes, and the cutting of wild hay from lands uncovered annually along the shores of Goose and Warner lakes.

IRRIGATION ENTERPRISES.

The character of irrigation enterprises in Oregon before the advent of the U. S. Reclamation Service can be inferred from the census report for 1902, where the total cost of the construction of reclamation works is given at $4.75 per acre. Diversions were made only where it was comparatively inexpensive. The diversion works and structures were crude and of the most temporary nature. The conservation of winter flood waters by storage has not been undertaken, except upon a most limited scale.

With the passage of the Carey and reclamation acts by the Federal Government, irrigation development received a stimulus, and irrigation enterprises ranging in cost from $25 to $60 per acre have been undertaken recently. The operations both by the State and by the Government under these acts are dependent upon the State laws governing the use and distribution of water. Only such projects as are comparatively free from water-right complications, or where it is clearly apparent that a large excess of unappropriated water exists, can be undertaken.

The development now under way under these laws will be discussed in detail, while the development by private capital and the future possibilities will be referred to under the head of stream systems or counties.

UNITED STATES RECLAMATION SERVICE.

Investigations were first begun in Oregon by the U. S. Reclamation Service in 1903. The Malheur River and Harney Valley projects at first appeared most promising, and detailed surveys were prosecuted with a view to early construction. These projects were abandoned on acount of certain complications, and preliminary work commenced in 1904 on the Umatilla and the Klamath projects. Up to June 30, 1907, $796,330 had been expended on the Klamath project within the State, and $496,993 on the Umatilla project, a total of $1,293,323 for both.

EAST UMATILLA PROJECT.[a]

The 20,000 acres of irrigable land included in the Umatilla project is located east of the junction of the Umatilla River with the Columbia River. The land lies comparatively level, at an elevation of 470 feet, and is favorably situated as to transportation facilities. The Union Pacific's main line from Portland to Chicago passes through Hermiston, a new town on the south side of the irrigated district, and a branch line to Spokane and the Idaho mining districts passes

[a] Information from Sixth Annual Report, U. S. Reclamation Service, F. H. Newell, Director.

along the north side of the tract. With the completion of the Government canal and locks in the Columbia River, between The Dalles and Celilo, water transportation to Portland and the ocean will be open to Umatilla without the necessity of transfer over the present State portage railroad. There will then be competition between the rail and the water lines.

The soil is of basaltic origin and is light and easily worked. It is covered with sagebrush in its original state. The average annual rainfall is about 9 inches. In addition to this, 2.8 cubic feet per acre per annum will be supplied from the Government canals. The climate is extremely mild, almonds being successfully grown and all products being marketed two weeks or more in advance of those of other sections of the State.

There are 3,740 acres of public land and 16,700 acres of private land under the project. The public land can be secured in the same manner as homesteads except that the farm unit is reduced to 10, 20, and 40 acre tracts, depending on its distance from a shipping point, and the commutation clause of the homestead law does not apply. The construction cost of $60 per acre must be paid for both public and private lands in ten annual installments. Where private lands are purchased, residence within the vicinity must be established before water can be secured. The annual maintenance charge for the first year has been fixed at $1 per acre irrigated. The value of these lands with perpetual water right ranges from $150 to $250 per acre. The principal products will be fruit, vegetables, grain, and hay.

All structures on this project have been built of permanent material, with a view to the minimum cost of maintenance. A 25-mile feed canal of 300 cubic feet per second capacity has been built to convey the flood waters of the Umatilla River from a point near Echo to the storage reservoir at the upper edge of the lands to be irrigated. The diversion dam is of concrete and much of the feed canal is concrete lined. A storage reservoir of 50,000 acre-feet capacity has been provided by the construction of an earth embankment 98 feet in height with a top length of 3,500 feet. This was completed on July 1, 1908, and sufficient water stored for that year's crops. In the distribution system there will be 8 miles of canal of 50 to 225 cubic feet per second capacity, 50 miles with 10 to 50 cubic feet per second capacity, and 100 miles with less than 10 cubic feet per second capacity. Instead of constructing wooden flumes across depressions, 6¼ miles of reenforced concrete pipe, 30 inches in diameter or greater, has been constructed and 2 miles having a less diameter than 30 inches. This has been imbedded in the ground, forming an inverted siphon.

In addition to the storage provided, a large part of these lands will receive water direct from the Umatilla River during the spring when the river is in flood. Since only the waste flood waters of the Umatilla River will be used, either direct or by storage, there is no possibility of the Government water right being encroached upon through possible future litigation.

KLAMATH PROJECT.[a]

The Klamath project contemplates the reclamation of 187,000 acres of fertile land located largely in Klamath County, Oreg., and partly in Modoc and Siskiyou counties, Cal. Forty-five thousand acres of this land are in public ownership. The average elevation is 4,100 feet. The plan involves not only the irrigation of the valley lands but the drainage and ultimate irrigation of parts of Lower Klamath and Tule lakes, lands which are now either swamp or lake bottoms. Practically all of the uplands are held in private ownership, and in large tracts and must, under the terms of the Reclamation Act, be subdivided and sold in tracts not to exceed 160 acres in extent before water can be secured from the Government canals.

Construction work was authorized on May 17, 1905, and by June, 1908, 31 per cent of the entire project was completed and water was actually delivered to some 10,000 acres under water-right contracts.

The system is so designed that it can be constructed in units. The main water supply will be derived from Upper Klamath Lake, which has an area of 60,000 acres and will serve as a natural reservoir. The maximum recorded flow from this lake is 9,000 cubic feet per second and the ordinary low-water flow about 1,470 cubic feet per second. The main canal tapping this lake will have a capacity of 1,500 cubic feet per second. The upper project, which includes Langells, Youna, and Poe valleys, will receive water from Clear Lake, located in California. A dam 30 feet high and 850 feet long will be constructed at the lake outlet, furnishing a storage capacity of 460,000 acre-feet.

The average rainfall in this district is 15 inches, and the duty of water, as established, is 1½ acre-feet per acre. Irrigated lands range in value from $25 to $100 per acre.

The principal industry of this region has been stock raising, but with the completion of a branch line connecting with the main line of the Southern Pacific between Portland and San Francisco, the usual varied industries will rapidly spring up. The principal products will be alfalfa, grain, fruit, and vegetables.

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[a] Information from Sixth Annual Report, U. S. Reclamation Service, F. H. Newell, Director.

OTHER GOVERNMENT PROJECTS.

The Reclamation Service has investigated other projects for possible future construction, as follows:

The John Day-Umatilla project, involving 150,000 acres, at an elevation of 300 to 700 feet, bordering Columbia River.

The Malheur and Owyhee River projects in eastern Oregon, involving the possible reclamation of 120,000 acres, 2,200 feet above sea level in the great Snake River Basin.

The Harney Valley project, where the area is limited only by the available water supply of Silvies River. Elevation, 4,150 feet.

Silver Creek project, in Harney County, where perhaps 30,000 acres can be reclaimed through the construction of a 90-foot dam.

A withdrawal of 33,000 acres of land at the mouth of the Chewaucan River has been canceled by the Government in favor of a State project under the Carey Act, covering only 12,000 acres. The possibility of utilizing the 148 cubic feet per second constant flow on lands adjoining Ana River at the north end of Summer Lake, in Lake County, was also abandoned.

RECLAMATION BY THE STATE.

Under the provisions of the Carey Act 432,203 acres of arid land has been selected by the State for reclamation. This act provides that the Federal Government will grant, without charge, to each of the States containing desert lands 1,000,000 acres, or as much thereof as the State shall cause to be reclaimed, provided such States bind themselves to dispose of the same in tracts of not to exceed 160 acres to actual settlers.

Under the Oregon law accepting the provisions of this act, the State transfers the responsibility of reclamation to persons or companies who make the selection and contract for its reclamation with the State Land Board, which is charged with the administration of the grant. This board is thus trustee for the proper expenditure of millions of dollars belonging to prospective settlers. The construction companies appropriate the necessary water, the same as any private person or company. Under the early contracts the construction companies were given a lien on the land to be reclaimed for the cost of construction and a perpetual right to operate the system, with the privilege of collecting a fixed annual maintenance charge. The settler, upon paying off this lien and making to the board proof of actual cultivation, reclamation, and settlement on not to exceed 160 acres of land, could secure a deed from the State without further cost. The early contracts with the State were very general in character and did not afford the settler sufficient protection. The orig-

inal lien, as provided for the companies, has been found in most cases too low. General dissatisfaction has thus resulted, causing the State Land Board much trouble. Where an increase of lien was granted by the State, a new contract, granting more protection to the prospective settler, was insisted upon. These new contracts are similar to those in use under the Idaho law, where operations under the Carey Act have been very successful.

Soon after the adjournment of the legislature in 1907, three contracts were executed by the State for the reclamation of 183,834 acres, at a cost to future settlers of $4,692,716.

THE DESCHUTES IRRIGATION AND POWER COMPANY.

The contract with the Deschutes Irrigation and Power Company provides for the reclamation of 140,714 acres of land in Crook County on the east side of the Deschutes River. The tract includes nearly all the land in a strip 15 miles wide by 25 miles long, and ranges in elevation from 2,700 to 3,600 feet. It has a somewhat uniform slope to the north of approximately 40 feet to the mile, and is covered with a scattering growth of sagebrush and juniper. The soil is of volcanic origin, light in color, and very productive when irrigated. About 30 per cent of the tract is waste, being occupied by low rock ridges.

This tract will be watered from the regular flow of the Deschutes River at Bend, which has an average flow during August of about 1,500 cubic feet per second. The main canal, which is nearly completed, taps the river 3 miles above Bend, divides into two branches 25 and 30 miles in length, respectively. It is designed to supply 1 cubic foot per second of water for each 70 acres.

A second canal is proposed to tap the river just below Bend, to supply 56,000 acres. The duty of water as fixed is 1 cubic foot per second for each 100 acres, delivered on the land. Water is to be delivered by the company to the highest point of each 40-acre tract.

Lands are opened for entry and sale in districts as rapidly as the main canals and main laterals are completed. The price as fixed by the State is $40 per acre for the irrigable land, and $2.50 for the waste land. At the end of ten years from June 17, 1907, the control and management of the system is to be transferred to the settlers. Pending this transfer, the company is authorized to collect an annual maintenance charge of 80 cents per acre. Under the old form of contract, 40,591 acres have been sold. The company will retain a corresponding interest in the system at the time of the transfer of management and continue to supply water to these lands at $1 per irrigable acre per annum, unless a further payment of $6 per acre is made. This additional payment will put the holders of old contracts upon an equal footing with purchasers under the new contract.

Patents have been issued to the State for 35,683 acres, and up to August 1, 1908, 17,552 acres have been opened for sale by the company under its new contract.

Bend, the company headquarters, on the southern extremity of this tract, is 90 miles by stage south of Shaniko, the nearest shipping point. It can be reached over the Oregon Railway and Navigation or Union Pacific lines, transferring at Biggs to the Columbia Southern Railway.

BENHAM FALLS SEGREGATION.

The Deschutes Irrigation and Power Company, through the State, has selected 74,198 acres of desert land east of and adjoining the above tract of 140,714 acres. No contract for its reclamation has as yet been executed with the State.

This land has a uniform slope and a deep soil and is unbroken by lava-rock ridges. It is proposed to supply this tract by storing the winter flow of the Deschutes River in Crane Prairie, about 30 miles above Bend. Here a 40-foot dam will store 276,825 acre-feet of water.

THE DESCHUTES LAND COMPANY.

This company proposes to reclaim 31,082 acres in the Deschutes Valley, about 35 miles above Bend. The land is located in townships 21 to 23 south, range 10 east. The soil is decomposed pumice stone, devoid of humus, but appears to produce hay, clover, and all the hardy vegetables which can be grown at an elevation of 4,300 feet. A narrow natural meadow, due to an underground river, terminating at the bank of the Deschutes, passes through the tract, and water can be found at any point in the entire tract within 10 to 20 feet of the surface. This land, together with much of the surrounding country included within the National Forests, is covered with a thick growth of black or jack pine, 50 to 100 feet in height. These trees have no taproots, can be easily cleared, and have no value except for wood, fences, etc.

The amount of water to be supplied for reclamation, as fixed in the contract with the State, is 2½ acre-feet per acre. This will be secured partly from the regular flow of the East Fork of the Deschutes River, but largely by storage in Crescent Lake, which is admirably suited for storage purposes.

Construction work was not commenced within the time specified in the State's contract, and it is doubtful if the time will be extended, as two contests which were filed against typical tracts have been decided adversely to the State's project. It has been held by the local land office that the land in question, without irrigation, "will produce agricultural crops in amount sufficient to make the cultivation thereof

reasonably remunerative, and that said land is not desert in character." If other contests are similarly decided, this project will doubtless be abandoned and the land will be thrown open to entry under the Federal laws.

PORTLAND IRRIGATION COMPANY.

It is proposed by this company to reclaim under the Carey Act a tract of 12,037 acres, located in the northern part of Lake County, by storing the waters of the Chewaucan River. This tract is the usual sagebrush land common to eastern Oregon. It has a uniform gentle slope, and lies between Summer Lake and the Chewaucan Marsh.

The reservoir site is located on the stream channel 20 miles above the land and is the same as that contemplated for use by the Government in its proposed project. Forty-two thousand eight hundred acre-feet is to be impounded by the construction of an 80-foot loose-rock and earth-fill dam.

The average price for sale of water rights as fixed in this company's contract with the State is $35 per acre. When 80 per cent of the lands is sold the system is to be transferred to an association of water users. Work has not been commenced.

COLUMBIA SOUTHERN PROJECT.

This project contemplated the reclamation of 27,000 acres of land on the west side of the Deschutes River, in the vicinity of Laidlaw and directly opposite the project of the Deschutes Irrigation and Power Company. The contract was one of the first to be executed by the State Land Board under the provisions of the Carey Act, and has given the State much trouble.

The water supply was to have been derived from the regular flow of Tumalo Creek, which was reported to the State at the time of contract as having a maximum flow of over 3,200 cubic feet per second and an average flow during June of 1,200 cubic feet per second. After about 20,000 acres had been sold at an average price of $10 per acre it developed through systematic measurements that the maximum flow of the stream did not exceed 425 cubic feet per second, and the low-water flow was less than 100 cubic feet per second. The canal system was poorly designed and imperfectly constructed. During 1906 all the available water supply was diverted into the system and it proved inadequate to irrigate 2,000 acres then under cultivation by settlers. Prospective settlers learning of the shortage have refused to move into the district, and some of those who had established residence have been compelled to leave. The main canal at the intake has a capacity of 130 cubic feet per second. Within a distance of 7½ miles

it drops 1,000 feet, with a loss of about 38 per cent of the water admitted. From the intake to the lower end of the tract is a distance of 20 miles, and the loss of water for the project as a whole will probably reach 50 per cent of that admitted.

Some of the land already sold under this project was disposed of under the claim that residence was not required in securing deed from the State, and some of the purchasers have brought suit to recover. A mortgage of $175,000 has been placed on the system. Before the shortage of water was discovered, 11,660 acres had been patented to the State. About equal amounts of the patented and unpatented land have been sold. The company's contracts with the settlers, in most cases, did not specify any particular amount of water to be furnished. The State Land Board insisted that some reasonable duty of water should be established, but the company maintained that since they had dug the required canals and had delivered the available water they had complied with their contract. This disagreement forced the State to begin suit for cancellation of contract and an accounting of funds. A decision in the case will probably soon be reached, and the way cleared for letting a new contract. In a reservoir site at the upper edge of the tract all surplus waters of Tumalo Creek can be stored by the construction of a 70-foot dam. This, with the regular flow of the stream, will be more than ample to reclaim the segregated lands.

IRRIGATION BY PRIVATE ENTERPRISE.

The development of the State through irrigation undertaken by private enterprise will be discussed by counties or stream systems. Owing to the fact that Oregon has but recently assumed direct control of its water resources, and created a board with power to regulate diversions, but little detailed information is available.

MALHEUR COUNTY.

Probably more money has been expended in Malheur County in the development of irrigation by private enterprise than in any other county in the State. This development has taken place mainly in the broad valley through which the Malheur River flows in the lower 30 miles of its course, and along Snake River for a distance of 30 miles north of the Owyhee. It is estimated that, in addition to the 50,000 acres already under partial irrigation within this district, there is approximately 100,000 acres of land which can be reclaimed ultimately through the storage of water in reservoir sites along Malheur and Owyhee rivers, Bully Creek, and Willow Creek. The larger of these reservoir sites have been fully investigated by the

Government and private parties, and found adequate to store the entire winter and flood water flow of these streams. The regular low-water flow of these streams is already fully utilized.

With the recently created administrative machinery for the distribution of water, the use of natural stream channels for conveying stored water past present constructed ditches to the place of use will be made possible. Thus, one of the principal difficulties in the way of Government development will be overcome. If the larger projects are not taken up soon, the way will be open for private capital in the numerous small possibilities.

The flow of streams in this district falls off rapidly between June 1 and July 1, and much of the land already irrigated could be greatly benefited by supplementing this regular flow with stored water.

In 1903, 22 ditches diverted water from Bully Creek upon the narrow strip of bottom land east of Westfall. In addition to the regular flow of Willow Creek, much of its flood water is diverted upon the low adjoining lands during the early spring, making possible the production of alfalfa. The following table gives the important ditches which in 1903 diverted water from the Malheur River from its mouth to 16 miles above Vale, where the river emerges from a narrow canyon:

Ditches from Malheur River in lower 35 miles.

Name.	Length.	Computed maximum capacity.	Name.	Length.	Computed maximum capacity.
	Miles.	*Cu. ft. per sec.*		*Miles.*	*Cu. ft. per sec.*
Brosman ditch	4	18	Linebarger ditch	3	15
Malheur Butte ditch	20	144	J. H. ditch	12	50
Nevada ditch	20	40	McLaughlin ditch	5	19
Vale Milling Company	2	30	Malheur Farmers ditch	8	68
Sand Hollow ditch	6	10	Scott-Vines ditch	5	13
Gillerman Froman	8	66			

A large ditch 25 miles in length, with a maximum capacity of 200 cubic feet per second, diverts water from the Owyhee about 12 miles above its mouth. It runs parallel with and about 2 miles distant from the Snake River to Ontario, watering much of the land below it. The canal capacity exceeds the low-water flow of the Owyhee River. The Owyhee has a drainage area of 9,880 square miles, with a maximum recorded flow of 20,000 cubic feet per second. Plans have recently been filed in the State engineer's office for four reclamation enterprises involving storage on the headwaters of this stream. With the exception of lands along Jordan Creek, in the vicinity of Jordan Valley, but little irrigation development has taken place in the Owyhee drainage basin.

BAKER COUNTY.

Powder River Valley, 25 miles in length by 7 in width, traversed by the Oregon Railway and Navigation Division of the Union Pacific Railroad, is the principal agricultural section of this county. Perhaps 25 per cent of this area is irrigated at the present time, consuming the regular summer flow of Powder River and the numerous smaller streams which enter the valley from the west. The valley is almost entirely in private ownership, as grain crops can be produced without irrigation. No large ditch systems have been constructed, since water can be readily diverted from the river at any point.

The Kilmerque Reservoir, at the head of Rock Creek, having a capacity of about 2,000 acre-feet, was built to supplement the flow of this stream for hydro-electric power development, and later used for irrigation purposes. The largest and only other storage development in the valley is that of the Baker Irrigation Company. The flood waters of Powder River are conveyed by an 8-mile canal to a reservoir site near Baker City. A hydraulic fill dam 2,000 feet in length and 50 feet high is now under construction. The reservoir when completed will submerge 240 acres. About 10,000 acres adjacent to Baker City will ultimately be reclaimed by this system.

Lower Powder Valley, 12 miles in length by 1 in width, located about 15 miles northeast of Baker City, is partially irrigated by 6 ditches, ranging in capacity from 8 to 30 cubic feet per second. In Powder River Canyon, 9 miles above this valley, a 90-foot dam 450 feet in length can be constructed, which would store 36,000 acre-feet. Ten miles of main side-hill canal and 40 miles of lateral canals will convey this water to the 33,000 acres of bench land adjoining and including the Lower Powder Valley, which is flooded in spring and insufficiently watered in summer.

A 40-foot hydraulic fill dam, 500 feet long and 25 feet wide at the crest, has been constructed by Walter Love on a creek flowing into Lower Powder Valley, in order to secure water for 160 acres of bench land. The creek carries water for only a few days each year. This flow was used to wash earth into the dam, depositing the heavy material on the lower side, the finer material being carried into the reservoir, where it settled, forming a strong, impervious embankment which conserved the water for summer use. After eight years the dam, together with feed-water ditches to increase the reservoir drainage area to 13 square miles, was completed at a cost of $2,250. Nine hundred acre-feet of water was secured from this area. Practically no hydraulic head was available for construction. Water was flushed across ground having a slope of 7 inches to the rod and,

assisted by a road grader, the muddy water was scraped into a flume having a fall of 5½ inches to the rod, which conveyed it to the dam site where, by adjustment of flumes, it was deposited at the desired points.

Messrs. Love, Moore, and Jacobs are associated in the construction of an 88-foot hydraulic fill dam on Birch Creek, near Huntington, for the irrigation of 2,000 acres. The water supply for the hydraulic work is very inadequate. In 1906 five men, working twenty-five days of three and one-half hours each, constructed the lower 26 feet of this dam with a crest 200 feet in length. A flume, 18 inches bottom width with 16-inch sides having a grade of 12 inches to the rod, was used to convey the material into the dam. Bowlders weighing as much as 50 pounds are reported to have been sluiced into place, and the flume is reported to have required relining every four days on account of the heavy material transported.

The construction of a number of similar dams in this vicinity is now contemplated. In one case a flume over 2,000 feet long has been built to convey material to the dam site. Many opportunities for this character of development exist in this county, as well as in all parts of the State.

The most highly developed section of Baker County, through irrigation, is perhaps Eagle Valley, about 35 miles east of Baker City. It is about 2 by 3 miles in extent and located in the heart of the mining district. The water supply is more than ample to reclaim all available land. Pine Valley, about 8 miles to the north of Eagle Valley, is also well developed. It will average 10 miles in length by 2 in width. The water supply is inadequate without storage. Considerable irrigation occurs along Upper Burnt River, principally through abandoned mining ditches, some of which are 20 to 60 miles in length.

UNION COUNTY.

This county includes much of the Grande Ronde River drainage basin. Its principal agricultural section is in the Grande Ronde Valley, about 12 by 20 miles in extent, almost level, and averaging 2,700 feet in elevation. Grain can be produced without irrigation, and until recently irrigation was not thought necessary. The low-water flow of all streams entering the valley is now put to beneficial use. A beet-sugar factory, recently constructed near La Grande, has greatly stimulated irrigation development. Plans have been announced recently for the construction of a large reservoir on the Grande Ronde above La Grande, and one on Catherine Creek above the town of Union. The main and branch lines of the Union Pacific Railroad system traverse the valley, furnishing adequate transporta-

tion facilities. The fruit industry of this district is rapidly coming to the front on account of the good shipping qualities of the product.

WALLOWA COUNTY.

Some of the highest mountains in the State are found in Wallowa County. Wallowa Valley, extending from Wallowa to Joseph, is highly developed through irrigation. Many ditches have been constructed and the regular flow of the stream has been supplemented by the construction of a dam at the outlet of Wallowa Lake. A railroad is at present being constructed into this county. Rapid development may be expected within the near future, as the natural resources of the county are great and diversified.

UMATILLA COUNTY.

The summer flow of the Umatilla River and tributary streams and also of the Walla Walla River has been fully utilized. These two rivers are the principal streams of the county. Several large ditches have been built, where the application of flood waters during spring freshets is relied upon to produce paying crops. As yet no storage has been undertaken, except by the U. S. Reclamation Service. The figures given for this district in the chapter on water resources (p. 17) indicates that much surplus water is still available.

The Umatilla Valley above Pendleton is occupied by an Indian reservation, on which wheat is grown without irrigation. From Pendleton the river flows through a comparatively narrow canyon to Echo, at which point the hills recede, leaving a valley 5 miles in length and containing about 10,000 acres. It then narrows down until it reaches the mouth of Butter Creek, where the valley gives way entirely to bench land.

It will be observed by consulting the following table that 19 ditches divert water from this river. The Oregon Land and Water Company diverts water for the irrigation of desert land along the Columbia River near Irrigon. The Brownell Ditch Company has a small Carey Act holding along the Columbia River near Umatilla. The land of the Maxwell Land and Irrigation Company, which has been taken over by the Reclamation Service, was bench land in the vicinity of Hermiston. The Inland Irrigation Company contemplated the irrigation of bench land on the north side of the river near Foster by the diversion of spring flood waters. The Henkle Ditch diverts water from the river a few miles above Echo and extends to Butter Creek. The remaining ditches supply water for the irrigation of bottom lands in the vicinity of Echo or in the canyon immediately above.

Ditches from Umatilla River, Pendleton to its mouth.

Name of ditch.	Maximum capacity.	Acreage cultivated, 1905.	Gross acreage controlled.	Name of ditch.	Maximum capacity.	Acreage cultivated, 1905.	Gross acreage controlled.
	Cu. ft. per sec.				*Cu. ft. per sec.*		
Parker ditch	1.5	40	60	Hinkle ditch	250	800	
Mill ditch at Echo	18	40	100	Crane-Lisle ditch	10	250	375
Allen ditch	27	1,060	2,400	Maxwell Land and Irrigation Co	175	300	9,000
Chas. Lisle ditch	10	100	175	Wilson ditch		130	200
Maxwell-Dillon	18	600	1,700	Horseshoe Irrigation Co	20	40	200
Beitle ditch	4	225	240	Inland Irrigation Co	130		10,000
Pioneer & Courtney	24	300	1,080	Stanfield Irrigation Co			530
Slusher & Gould	3	60	100	U. S. Reclamation Service	300		
Oregon Land and Water Co	66	600	4,500	Olivers ditch			
Brownell ditch	13	45	900	Ott & Carpenters ditch			

These ditches have been arranged in order of their priority of appropriation of water. The relative order, amount of appropriation, and area controlled are not definitely known, as the State water-right records are imperfect. The information has been compiled from the most reliable sources for the year 1905, and is given here only as a basis for further investigation by prospective settlers in this district or for those who contemplate the making of further appropriations from the Umatilla River.

The Walla Walla Valley, in the eastern part of this county, is one of the oldest, and at the present time the section of the State most highly developed by irrigation. Only 5,000 acres of the 20,000 located between the State line and the point where the river leaves the mountains is cultivated, but this consumes the entire summer flow. The irrigated land is cut up into farms of 2 to 15 acres in extent, nearly every farm having its own ditch diverting water from the river. Over 500 carloads of fruit were shipped from this district during 1907. Irrigated land is worth from $400 to $1,200 per acre.

The Walla Walla River falls from 50 to 80 feet to the mile, and more water power is developed in proportion to its size, perhaps, than along any other stream in the State. The low-water flow of approximately 100 cubic feet per second supplies power for three flour mills, aggregating 120 horsepower, one planing mill, one municipal hydro-electric power plant of 130 horsepower, and one private hydro-electric power plant of 2,500 horsepower capacity.

The ease with which water can be diverted from this stream has led to overappropriation. Litigation has been under way for many years to determine the relative rights. In 1905 a general suit was commenced, and the State engineer was ordered by the court to make a general survey of the entire district as a basis for the adjudication. This survey cost 17 cents per acre and shows classification of lands and culture, all roads, fences, streams, 10-foot contours, etc. In a distance of 10 miles 190 ditches were found tapping the stream. Weekly

measurements of these ditches and of the stream at sixty different points were kept up throughout a complete year for the benefit of the court. The general stream duty for July, 1906, was found to be 2.2 miner's inches to the acre, and during August 1.7 inches (40 inches equals 1 cubic foot per second). The water applied to three typical tracts was accurately measured from April 15 to September 15 by representatives of the Office of Experiment Stations, U. S. Department of Agriculture, and 9, 17, and 22 acre-feet per acre, respectively, was found to have been used.

HOOD RIVER AND WASCO COUNTIES.

In the counties to the west of Umatilla but little irrigation development has been undertaken, except in Wasco and Hood River counties. The summer flow of Willow Creek is quite limited and has been fully utilized on adjoining lands. John Day and Deschutes rivers, in the lower 75 miles of their courses, have cut for themselves canyons 500 to 2,000 feet in depth through layer after layer of lava, which underlies the great rolling wheat district of Morrow, Gilliam, and Sherman counties.

Wasco County is broken by many small streams, which rise in the high mountains to the west. These furnish innumerable opportunities for development on a small scale, but only the most inexpensive diversion points have so far been utilized.

Hood River County has been created recently from that portion of Wasco County which is drained by Hood River. Bearing orchards in this district have been sold for as much as $2,000 per acre, and it is claimed will regularly pay good interest on $5,000 per acre. The development near transportation has been rapid within the last few years, and the building of a branch line up the valley has paved the way for further development. The principal crop is apples, though all varieties of fruit and berries are grown. Irrigation is necessary for the highest development. Three large canals have been constructed already in the broad lower valley, where diversions are more difficult than in the narrow valleys higher up on the stream. The summer flow of Hood River far exceeds the present demands for irrigation.

CENTRAL OREGON.

This district is comparatively undeveloped, on account of lack of transportation facilities. There are innumerable opportunities for profitable investment prior to the completion of the railway lines now being extended into the territory.

John Day River heads in comparatively broken country and flows through no valley of any great extent. Between Dayville and Prairie

City considerable undeveloped bottom land exists, and some bench land which can be readily irrigated can be found along this stream or its numerous tributaries.

On the Deschutes River there is but little opportunity for the diversion of water below Bend, as the river enters a deep canyon at this point. The operations of the State above Bend under the Carey Act will ultimately consume the regular summer flow of the stream. Innumerable lakes occur on the headwaters and sufficient irrigable land can be found to consume the entire flow of the district if storage facilities are provided.

Only the most inexpensive irrigation projects have been undertaken in the great interior basin. Here the run-off is all taken up by evaporation or lost by seepage. This vast inland basin has no visible outlet, and all of it is over 4,000 feet in elevation. It is principally a stock country.

Harney Valley, 25 by 40 miles in extent, contains the largest body of level land and produces more hay probably than any other section of the State. Silvies River enters this valley from the north a few miles above Burns. Its flood waters are diverted and spread out over an immense area through the construction of 13 dams and 18 short ditches. This thin sheet of slowly moving water fails during the highest floods of some years to reach Malheur Lake. One crop of wild hay, averaging about 1 ton per acre, is cut from the flooded district. Prof. I. C. Russell, of the United States Geological Survey, states that the waters of Malheur Lake are comparatively fresh and suitable for use in irrigation. The swamps of the Blitzen River have been converted into an extensive hay ranch by the construction of a large canal to Malheur Lake.

Storage is possible along most of the many streams and draws which enter Harney Valley, and domestic water of good quality can be found within 10 to 20 feet of the surface at most points in the basin. On the bench land around the edge of the valley potatoes and grain crops have been successfully grown without irrigation, and many settlers familiar with the conditions in the famous wheat belt in the northern part of the State have taken up recently bottom lands in Harney Valley, claiming that certain grain crops can be successfully produced without irrigation. All of the hardy fruits and vegetables have been successfully grown in the vicinity of Burns with the aid of irrigation. On the east edge of the valley peaches of excellent quality have been produced.

Christmas Lake, in the northern part of Lake County, is strongly alkaline, and is apparently the lowest point in a great basin containing between 300,000 and 400,000 acres of almost level land, covered with a thrifty growth of sagebrush. The water of Silver Lake is

fresh and overflows during floods into Thorn Lake, which in turn overflows into the desert toward Christmas Lake. This immense area is underlaid with a sheet of pure water from 10 to 20 feet below the surface. During the past year a hundred or more families have taken up homesteads within the vicinity, believing that the annual rainfall is sufficient to produce grain crops. The geology of this region has been studied by representatives of the United States Geological Survey, and Christmas Lake and Harney valleys have been declared to be natural artesian basins. Indications point so strongly to this conclusion that settlers are advised that they will be warranted in making the expenditure of sinking a test well.

Paulina Marsh has been converted into an immense hay ranch by drainage into Silver Lake. The low-water flow of tributary streams is diverted through a number of ditches. Litigation as to its proper distribution has been under way for eight years. Sycan Marsh has been converted into a hay ranch through drainage. The surplus water flowing into this marsh can be diverted across the divide into Silver Creek by the construction of two short canals. The waters of Summer Lake and Abert Lake are strongly charged with potash, soda, and other salts. Chewaucan Marsh, lying between these two lakes, has been converted, through the construction of several extensive drainage canals, into a 25,000-acre hay ranch. A number of canals divert water from the Chewaucan River near Paisley for the irrigation of some 1,200 acres adjoining the upper edge of this marsh.

The water from numerous small streams entering Summer Lake from the west has been diverted for irrigation purposes, and phenomenal results for an elevation of 4,500 feet have been secured. The most delicate fruits and vegetables, including apricots, tomatoes, etc., have been successfully grown. The almost vertical wall of lava, rising to 1,500 to 2,000 feet above this lake and paralleling its west shore, perhaps accounts for the somewhat unusual climatic conditions of this district.

Considerable wild hay is cut each year along the shores of Goose and Warner lakes, and the summer flow of tributary streams is diverted for irrigation purposes. Better transportation facilities for this central Oregon region seem assured now, and it is believed that this comparatively undeveloped section of the State will offer exceptional opportunities for the home builder and investor.

WESTERN OREGON.

In western Oregon no expensive reclamation works have been constructed. While irrigation has been practiced in southern Oregon for many years it is only recently that the great value of water has

been realized. The immense returns reported for orchards in this section can not be secured without irrigation. With the growth of the fruit industry and under the recent favorable legislation more expensive projects will be undertaken.

LAWS GOVERNING THE CONTROL AND USE OF WATER.

Up to 1909 the water laws of Oregon were not favorable to the development of irrigation. Many sections of law bearing on the subject were enacted, but these provided no comprehensive system of control and lacked a general penalty necessary to make them effective. The supreme court held that it was not necessary to comply with these laws in order to establish a valid appropriation. To get at the law governing water rights in Oregon before the enactment of the 1909 law it was necessary to examine not only the statute law but also the many court decisions.

Oregon was admitted as a State on February 14, 1859. The fact that its constitution contains no provisions relating to the use of water can be accounted for only by the fact that a majority of the population then, as now, lived in the western or more humid portion of the State. In 1893 and 1895 a constitutional amendment was approved by the legislature making up for this deficiency, but it was voted down when submitted to a vote of the people.

COURT DECISIONS.

In the absence of constitutional provisions or statute law governing waters, the early decisions of the supreme court followed closely the old English common-law doctrine of riparian rights without regard to the conditions or needs of the State. This is indicated in the following quotation from the earliest decision bearing on the question:

> Running water is not susceptible of an appropriation which will justify the diversion or unreasonable detention of it. * * * Every riparian proprietor is entitled to the use of the flow of the water in its natural course, and the momentum of its fall on his own land. He has no property in the water itself, but a simple usufruct. (Lord) Weiss *v.* Oregon Iron Company, 13 Oreg., p. 496, June, 1886.

This strict adherence to the doctrine of riparian rights was soon modified so as to permit the diversion and the reasonable use of water for irrigation purposes, as indicated by the following abstracts:

> Riparian proprietor * * * if his wants are supplied and he has sufficient water for his beneficial use, he ought not to complain because others above

divert the water. His right of action is based upon his injury, and if his wants are all supplied he can not be injured. To hold that after the needs of a prior appropriator have been supplied he, as a riparian proprietor, was entitled to the flow of the excess beyond his appropriation in the channel of the stream would be to deny all subsequent appropriations. Such a rule would destroy the very object for which the theory of irrigation was established and would give the prior appropriator the use of all the water in a stream without regard to its size or capacity. (Moore) Low *v.* Schoffer, 24 Oreg., p. 239, 1893.

A court of equity should not ignore the use of water for a beneficial purpose, unless it appears that other riparian owners will be materially injured. (Bean) Jones *v.* Conn., 39 Oreg., p. 30, 1901.

In a recent decision it was held that the act of Congress, March 3, 1877, known as the "Desert Land Act," abrogated the modified doctrine of riparian rights as to all lands subsequently acquired from the United States:

The language used in this act was clearly intended to change the rule respecting the right of riparians to the use of water for irrigation, mining, and power purposes; but, as in the last case cited, it has its limitations. It does not go so far as to affect the rights originally giving rise to the doctrine of riparian rights, that is, for domestic use, including the watering of domestic animals and such stock as may be essential to the sustenance of the owners of lands adjacent to the streams or other bodies of water. (King) Hough *v.* Porter, 98 Pac., 1083, Jan. 5, 1909.

While some of the many decisions apparently conflict, it is believed that the above quotations represent the general trend of the court decisions as regards the irreconcilable conflict between riparian rights and the doctrine of appropriation.

It is becoming generally known that irrigation is as essential to intensive farming in western Oregon as in eastern Oregon, and that the entire State is arid in nature. The law governing the appropriation of water should, therefore, be the same for all sections of the State and should not be essentially different from that applied in Nevada or other arid States. The Oregon court decisions apparently closely follow the California doctrine of riparian rights as laid down in the leading case of Lux *v.* Haggin, 69 Cal., p. 255. The California court, in deciding this case, according to Wiel on water rights, relied upon the Nevada case of Van Sickle *v.* Haines, 7 Nev., p. 249, wherein the common-law doctrine was strongly upheld. Later the Nevada court, in Reno, etc., Works *v.* Stevenson, 20 Nev., p. 269, overruled all its decisions and declared the common law of riparian rights utterly unsuited to conditions in Nevada and not existing there. It reaffirmed this later position in Walsh *v.* Wallace, 26 Nev., p. 299.

The tendency of the Oregon courts, as of those of other western States, has been to lean strongly toward the single basis of priority of appropriation and beneficial use where the two conflicting bases for the adjudication of water rights have been introduced.

STATUTE LAW.

The first statute concerning the use of water was enacted in 1891. This law declared "the use of the water of the lakes and running streams of the State of Oregon * * * to be a public use, and the right to collect rates or compensation for such use of said waters is a franchise." It provides for the appropriation of water for irrigation purposes by corporations only and the condemnation of rights of way therefor. Within ten days after the posting of a notice at the proposed point of diversion a copy of such notice must be filed for record with the county clerk. Within six months after the date of posting such notice the actual work of construction must commence and be prosecuted diligently to completion. The actual capacity of the ditch or flume, when completed, determines the extent of the appropriation. No provisions were made for either the completion of public record by the filing of proofs of completion of works or for the forfeiture of rights to the public in case of failure to complete the proposed works.

In 1899 a similar law was enacted providing for the use of water for mining and electric-power development by persons, companies, and corporations.

In 1905 the office of State engineer was created and provision made for the appropriation of water for irrigation purposes by any person, association, or corporation. Notices must be filed with the State engineer, in addition to the usual record with the county clerk, as provided in the earlier law. No penalty was provided to compel record at either place, and no limit was placed on the amount each appropriator could claim, even though it far exceeds the total flow of the stream. Only corporations can condemn the necessary rights of way. The State engineer had no control over the use or distribution of public waters. The records of his office and those of the county clerk as to water appropriations were incomplete. There was thus no way of determining definitely from any public record either the amount of water already appropriated, the amount to which rights may become vested within a reasonable time, or the amount of unappropriated water which may remain in any stream.

PUBLIC RECORDS.

The public records under the early laws, if considered seriously, would prevent forever the acquirement of any further rights to the use of water within the State. The recorded claims to water on the important streams of five eastern Oregon counties for irrigation purposes are shown in the table following.

Water filings as recorded in five eastern Oregon counties.[a]

Stream.	Irrigation.		Mining, power, etc.		No purpose named.		Total.	
	Number.	Amount.	Number.	Amount.	Number.	Amount.	Number.	Amount.
		Sec. ft.		*Sec. ft.*		*Sec. ft.*		*Sec. ft.*
Umatilla River	106	71,666	10	8,301	.....	.....	116	79,967
Walla Walla River	22	1,906	9	1,974	.....	.....	31	3,880
Miscellaneous, Umatilla County	6	60	43	760	.....	.....	49	820
Grande Ronde River	85	5,436	88	3,669	7	28	180	9,133
Miscellaneous, Union County	90	1,029	144	1,837	17	108	251	2,974
Wallowa River	42	3,339	21	10,143	30	1,313	93	14,795
Imnaha River	29	625	25	279,957	8	1,130	62	281,712
Miscellaneous, Wallowa County	36	2,770	13	414	10	44	59	3,228
Powder River	542	26,023	573	25,461	30	5,433	1,145	56,917
Burnt River	222	2,035	240	3,279	25	219	487	5,533
Miscellaneous, Baker County	108	1,245	126	38,233	1	2	235	39,480
Malheur River	270	232,008	68	651	31	674	369	233,333
Owyhee River	169	62,950	2	.....	3	252	174	63,202
Miscellaneous, Malheur County	137	14,909	36	130	4	12	177	15,051
Total, five counties	1,864	426,001	1,398	374,809	166	9,215	3,428	810,025

[a] Prepared for the First Biennial Report of the State Engineer by A. E. Wright, Office of Experiment Stations, U. S. Department of Agriculture.

The amount, in the aggregate, is sufficient to cover these counties to a depth of 23 feet each year. In addition to this, the total recorded claims to water for power development amount to more than fifty times the low-water flow of the Columbia River, whose low-water flow ranks next in volume to that of the Mississippi. Besides these appropriations of water for irrigation and power purposes, there were 19 claims to all the water of some of these streams, and 628 filings with no specific amount given. The absurdity of these claims is apparent when it is remembered that the average annual precipitation for this district will not greatly exceed 1 foot in depth. If all the rainfall appeared in the streams as run-off and no water was used for power purposes, not one twenty-third of the water filed on could ever be secured by the claimant.

The recorded claims to water for this district are typical of all county records where irrigation is practiced or water power developed. The total recorded claims invariably exceed the regular flow of the streams. The condition is complicated further by the fact that many ditches have been constructed and water diverted without any public record. As the records have not been completed by the making of proof of completion of work, it is impossible to ascertain how many of these filings have ripened into vested rights. To ascertain this would require in each case an examination of conditions on the ground and measurement of all ditches.

LITIGATION.

On account of the lack of a comprehensive system of State control of the diversion from streams much litigation has resulted. This is especially true in eastern Oregon, where the regular flow of the streams is inadequate to supply the needs of all. The new settler at the head of the valley diverts all he wants, leaving the fields of the pioneer irrigator below him to parch, and forcing the earlier settler into the courts to protect his right. The decree, when rendered, generally defines the right of the defendant alone; thus earlier irrigators may be compelled to maintain innumerable actions.

Litigation has thus been in progress for many years along the Walla Walla River in Umatilla County. Instead of settling titles to water, it has made them uncertain. Within a distance of 10 miles 190 ditches divert water from this stream or its numerous branches for the irrigation of 5,000 acres. Three large mills and two electric-light plants, besides many wheels which have been installed to pump water to bench lands, divert it for power. In 1905 a general suit involving about five hundred persons and corporations was begun, with a view to determining every right to the use of water along the entire stream.

STORAGE RESERVOIRS.

Oregon is generously provided with reservoir sites for the storage of winter and flood waters to supplement the low-water flow of her streams. The chapter on water resources will indicate an abundance of surplus water available for storage. To the knowledge of the writer there has so far been constructed only one reservoir where the natural channel of the stream is used in conveying the water to the place of use. The difficulties encountered in this case will illustrate why greater development along this line has not heretofore taken place in Oregon. The early law provides that natural channels of streams may be utilized by corporations in conveying stored water to the place of intended use, and that an equal amount, less that lost by seepage and evaporation in transmission, may be taken out again at any desired point. No method of protecting such water as it passes down the stream was provided. In the case referred to, a number of ditches tap the stream between the reservoir and place of intended use. As these ditch owners were unable to distinguish the difference between the stored water and that of the regular flow, all was consumed before reaching the desired point. The only storage systems of importance undertaken so far have been those in which the flood waters are carried through a large feed canal to a basin off the stream's channel and directly above the lands to be irrigated. This character of construction is more expensive and the possibilities of such development are limited.

RECENT LEGISLATION.

On February 24, 1909, an act providing for the regulation, control, and distribution of public waters became effective. In formulating this law the legislature profited by the experience of other States in the enactment of favorable water laws, and went a step in advance by limiting franchises to the use of water to a period of forty years from the date of application and by providing for the payment to the State of an annual license of from 25 cents to $2 per horsepower, depending upon the percentage of power appropriated which is put to beneficial use.

As noted below, water-right conditions on some of the streams had become so complicated that property was annually destroyed and lives threatened in personal conflicts to secure a proper division during the dry season. The commercial interests, seeing the great natural advantages of the State and their lack of development as compared with other States, finally joined with the water users in their efforts to secure State control of water resources. Under the new law the water user can, at small expense, secure a determination of his water right, with State protection thereafter, and the new appropriator or investor can secure protection and encouragement in the development of new enterprises.

DEFINING OF RIGHTS.

The responsibility of defining rights acquired prior to the adoption of the new law is placed upon a board of control, composed of the State engineer, as president, and the division superintendents of the two water divisions into which the State is divided. Upon a petition to the board, signed by one or more water users from a stream, a determination of all rights to the use of the waters of that stream will be begun, if, in the opinion of the board, conditions warrant. After thirty days' notice by publication the State engineer will begin a survey of the stream and ditches, the measurement of water used by the various claimants, and will gather all necessary data which can be secured upon the ground. The division superintendent of the proper division will then send by registered mail to each claimant to water or owner of land bordering the stream a blank form containing a list of questions. The claimant is required, under forfeiture of his right, to fill in the required information, giving the nature and amount of his claim and all essential facts required for a determination of his right. Each claimant is also required to pay in advance a graduated fee of 15 cents to 1 cent per irrigated acre, and 25 cents to 2 cents per horsepower, and $5 for any other character of claim to water. The division superintendent, upon the day fixed in the notice, proceeds to

collect these statements, which are certified under oath before him, and to take such further testimony as is necessary. Upon a certain date after completion of testimony, the evidence is submitted for the inspection of those interested. Within five days thereafter any claimant may contest the claim of any other, each being required to deposit a fee of $5 for each day required in the taking of testimony in the contest case. The deposit made by the winning party is returned. The original evidence, with that taken in contest cases, is then transmitted to the board of control, and as soon as practicable thereafter an order determining the relative rights is made.

The order of the board of control goes into effect immediately and can be enforced unless prevented in whole or in part by the filing of a stay bond. This order, together with the testimony, is filed with the circuit court of the proper county, and if no exceptions or appeals are taken the court enters an order affirming the order of the board. Appeals from the decree of the circuit court can be had to the supreme court if taken within six months from the date of such decree.

Upon final determination, water-right certificates are issued by the board of control to the parties interested, in accordance with the final decree of the court.

PROTECTION OF RIGHTS.

Each water division is divided into water districts as the rights along various streams are determined and the need therefor arises. Upon petition of one or more water users in such a district, a water master is appointed for the low-water period, who has authority to regulate diversions in accordance with determined rights, under the direction of the division superintendent. He has authority to make arrests and to compel the installation of necessary head gates and measuring devices for the enforcement of orders or decrees. As the stream supply diminishes, the ditches of most recent date having the poorest right are shut off and the water permitted to flow on to those having a better right.

If water is stored in a reservoir at the head of a stream, it is the duty of such water master, by regulating head gates, to protect such water when released into a natural channel, permitting its diversion by the rightful owner, less that lost by seepage and evaporation in transit.

ACQUIREMENT OF RIGHTS.

No right to the use of water can hereafter be acquired without compliance with the law of 1909. This law abolishes the old system of posting a notice on the bank of the stream. Priority of appropriation and beneficial use is the basis of all rights hereafter acquired, and water appropriated for irrigation is made appurtenant to the land irrigated.

The right will date from the receipt of an application in the office of the State engineer. This application will contain the name of the appropriator, the source of the water supply, the nature and amount of the proposed use, description of the works, the time for beginning and completion of works, and the time within which the water will be applied to a beneficial use. It shall be accompanied by a map of the proposed works and other information. The State engineer has authority to return the application for correction. The application does not become a permit to appropriate water until after its approval by the State engineer. He is authorized in making such approval to reduce the amount of the appropriation, or limit the time, so as to conform with the intent of the law.

The application should be accompanied by a fee of $3 for examining the same, together with additional fees, depending upon the proposed use, as follows:

For irrigation, graduated as follows:

15 cents per acre from 0 acres to 100 acres, inclusive.
5 cents per acre from 100 acres to 1,000 acres, inclusive.
1 cent per acre for each acre in excess of 1,000 acres.

For power, graduated as follows:

25 cents per horsepower from 0 to 100, inclusive.
10 cents per horsepower from 100 to 1,000, inclusive.
5 cents per horsepower in excess of 1,000.

For any other purpose, including applications by municipalities, $5.

Three different forms are provided for the appropriation of water—one to be used in case of new appropriations, another to be used where the appropriation is to be made by the enlargement or extension of existing works, and a third form where the application is for a permit to construct a reservoir and impound surplus waters. A separate application must be made for permit to appropriate stored waters prior to its application to beneficial use. This application is made on the first form mentioned above, and is then known as a secondary permit, and must refer to the primary permit and to the reservoir from which the water supply is to be derived. These forms, together with instructions, can be secured by addressing the State engineer, Salem, Oreg. They are simple and can be filled out by anyone, assisted, perhaps, by a surveyor, as a map of the proposed ditch is required as a part of each application.

Work must commence within one year from the date of application and be completed within a reasonable time, as fixed in the permit, not to exceed five years.

If the water is applied to the beneficial use within the time allowed, proof is taken of such fact by the division superintendent and a certificate issued the applicant by the board of control. This certificate is of the same form as issued to early appropriators upon determina-

tion of their rights, and is the foundation of his water right, the same as a patent from the United States is the foundation of his land title. Chain of title can thereafter be traced through the land records, as the law makes the water appurtenant to the land.

The penalties which will make this law effective and the public records complete and reliable are as follows:

It shall be a misdemeanor to use, store, or divert any water until after the issuance of a permit to appropriate such water.

Any person who shall willfully divert or use water to the detriment of others, without compliance with law, shall be deemed guilty of a misdemeanor.

The possession or use of water, except when a right of use is acquired in accordance with law, shall be prima facie evidence of the guilt of the person using it.

While it may appear impossible to determine and record all present vested rights under the new law, yet the experience of a number of States has demonstrated that this can be done, and at no greater cost to present ditch owners than the cost of an abstract of the titles to the land irrigated. The increased value of the water right, due to stability of title and assurance of State protection during the low-water season of each year, will easily justify this expense on the part of present ditch owners. Vexatious litigation and the necessity of personal supervision of the entire stream on the part of each irrigator will thus soon come to an end.

WATER RIGHTS UNDER CANALS.

Water rights acquired by purchase from canal companies are of many forms. Some convey a proportional interest in the ditch system, others provide for an annual payment for an indefinite time. Where a perpetual water right is purchased the contract may provide that the company shall retain the management of the canal at a fixed acre cost for maintenance or that the settlers under the canal shall assume the management after a certain time. In either case each settler would have to pay his pro rata cost of maintenance. Ditch riders, water masters, and a telephone system are as essential to the distribution of water from a large canal as the administrative system of the State is for the proper distribution of water to such canals. In no case can the water right under a large canal be any more certain or definite than the water right for such canal in the main source of supply.

In nearly all the Western States settlers interested in a common source of supply can organize under what is called an irrigation-district law and proceed to acquire water rights, construct irrigation works, distribute water, levy assessments, etc., along the lines of a municipal corporation.

From the standpoint of the water user, public control is necessary. To the average irrigator the measurement of running water presents such difficulties as to be entirely beyond his comprehension. With streams fluctuating from day to day and hundreds of ditches diverting water along the course of a single stream his conception of water rights is even more vague. The newcomer can readily measure off the land which he wishes to buy, check its description and area, and ascertain from an abstract whether the title is perfect. In many places in the arid portion of the State good land under constructed canals can be purchased for $5 or $10 per acre, where $75 to $100 or more is being asked for adjoining land identical in character. Upon inquiry it will be found that the latter has a water right, while the former has not. In those States having public control this water right rests upon a definite grant from the State and an abstract showing claim of title to it can be secured.

The importance of the legal status of a canal-water right and the provisions for just distribution during times of scarcity are generally overlooked by the new settlers. The earliest settlement along most streams has taken place at the lower ends of the broad valleys. Others came, settled above, diverted the water for irrigation, until there was not water enough for all. To protect the rights of the earlier settlers and to encourage others to settle on similar lands, the doctrine of priority of appropriation has been established as a basis of determining rights to the use of water. This doctrine, which is firmly established in most of the Western States, provides that the courts, in the absence of State control, will protect the rights to the use of water in the order of the date of its application to some beneficial use. In case of shortage the supply of the newcomer, even if a great corporation, will be cut off and the water allowed to pass on down the stream to the appropriator who began using the water at an earlier date.

If the water supply were far in excess of the demand there would be no necessity for such doctrine. The high value of irrigated land, as compared with that without a water right, is the cause for such rights being so bitterly contested for in the courts, where there is an uncertainty or an infringement of right. As streams fluctuate rapidly from day to day, it is impossible for the courts either to justly enjoin the use of water after a certain day each year, or to prescribe that each appropriator shall be entitled to a certain proportion of the entire flow. Since new conditions are constantly arising and changes of channels occurring, the doctrine of appropriation for irrigation purposes has been extended to the making of such water appurtenant to the land irrigated.

SETTLEMENT OF IRRIGATED LANDS.

It should not be presumed that settlers can come to Oregon without means, take up a Government homestead, secure a water right, and within a few years amass a fortune. Owing to the vast amount of railroad, logging, reclamation, and other development work going on in the State, the opportunities for the newcomer without means to accumulate money are greater, perhaps, than in the older settled States. Each settler, if he expects to undertake farming on his own account, should have from $1,000 to $3,000. His family will have to be maintained until the first crop can be marketed and he must purchase some necessary equipment. An experienced irrigator, or in western Oregon any good farm manager, with the smaller amount can rent land from the owners of large tracts at reasonable figures and within a short time clear sufficient to purchase the land. The early settlers acquired large holdings of land and are endeavoring to farm the entire area. To apply scientific methods of agriculture on these large holdings requires ability and capital as a rule beyond the power of the present owners. The result is that the owner of a farm of several hundred acres can barely make a living, while the man who gives careful supervision to the cultivation of 10 acres derives a comfortable income. A 10-acre tract in some of the irrigated sections of the State is often more than one family can handle. This principle of securing a larger proportional return from the careful cultivation of a small tract is so thoroughly demonstrated that the United States Government limits the amount of land that can be acquired by any one person under the Reclamation Act to less than 160 acres. On the Umatilla project 10 acres is the maximum quantity that can be secured in the vicinity of a shipping point. With $2,000 or more upon arrival the settler can secure enough land and purchase the necessary farm stock and machinery to make for himself a comfortable living. Land or water rights can be purchased under most of the existing canals upon the installment plan with interest on deferred payments. The lands being reclaimed in the vicinity of Bend under the provisions of the Carey Act are being disposed of at $40 per acre, payable in four annual installments, with interest at 6 per cent. Water rights under the Government Umatilla project can be secured at $60 per acre, payable in ten annual installments, without interest. If land in private ownership is purchased at $40 to $100 per acre, the water right must be paid for in addition. In the Willamette Valley the most fertile, partly improved land can be secured for $30 to $60 per acre. In a number of places 6 or 8 inch wells have been driven to a depth of 250 feet. Underground water can be secured within a few feet of the surface. As but few varieties of crops require irrigation in this valley, the

pumping of underground waters may prove the most economical means of securing a supply. This can be accomplished with a fuel cost of 7 cents per acre-foot for each foot of lift by gasoline engines, with distillate at 10 cents per gallon. The cost of securing gravity flow from the innumerable streams which enter this valley would be very small, as not even the cheapest diversion points have been taken up as yet.

In western Oregon the lumber needed by the new settler can be secured at the following prices f. o. b. at the mills:

Common rough lumber, per 1,000 feet	$10.50
Sized rough lumber, per 1,000 feet	11.50
Second-class flooring, flat grain	19.00
Second-class flooring, vertical grain	26.00
Rustic for outside coating	21.00
Shingles, cedar No. 1, per 1,000	2.25

In certain parts of eastern Oregon the prices are somewhat higher on account of freight charges. Small mills are scattered all through eastern and central Oregon, and lumber can be obtained in any part of the State at reasonable prices.

In order that the prospective settler may judge of the cost of farm machinery, as compared with prices in other parts of the United States, quotations of prices from a reputable firm have been secured, as follows:

Farm wagons, 3-inch-wide tire	$105.00
Steel plows, 14-inch	15.00
Rolling harrows, 8-foot	41.00
McCormick No. 4 mowers	60.00
Binders	150.00
Barbed wire, per pound	.04
Wire nails, per pound	.03½

While the profits from irrigated agriculture are much greater as a rule than are usually derived from agriculture in a humid State, there are certain additional expenses which should not be overlooked. If a gravity water supply is had, there is an annual expense of maintaining the canal, cleaning out silt deposits, or repairing the banks. If water is secured by pumping, the cost of maintenance and wear and tear on the machinery, as well as the cost of fuel, should be estimated. The usual cost of clearing land will be expected, but there is the additional expense of leveling or making it of uniform slope before the water can be best applied. Constant supervision is necessary throughout the irrigation season in spreading the water uniformly over the tract. Detailed information may be had by applying to the Office of Experiment Stations, United States Department of Agriculture, Washington, D. C., for bulletins on preparing land for irrigation and methods of applying water.

In a general way, those expenses which are peculiar to irrigated agriculture will run somewhat as follows:

Cost of preparing land for irrigation.

	Cost per acre.
Leveling land, hummocks 5 to 10 feet high	$3.00–$5.00
Leveling or uniformly sloping ordinary arid land	1.00– 3.00
Clearing sagebrush	2.00– 3.00
Plowing	1.00– 1.50
Annual cost of maintenance of canal system	.50– 1.50

The cost of applying water to the land varies with the method employed. The method depends largely upon the kind of crop grown and the character and slope of the land to be irrigated. Average prices are given in the following table:

Average annual cost of applying water by different methods.[a]

Method.	Average minimum cost per acre.	Average maximum cost per acre.	Method.	Average minimum cost per acre.	Average maximum cost per acre.
Check	$2.30	$4.90	Furrow	$2.10	$4.65
Flooding	1.56	3.95	Basin	3.00	6 00

[a] U. S. Dept. Agr., Office of Experiment Stations Bul. 145.

OPPORTUNITIES FOR SETTLEMENT.

Oregon has an area over twice that of Ohio. Its present population is about 600,000 as compared with 5,000,000 in Ohio. Land values are low, and all of the good opportunities for investment have not been taken up as in an overcrowded State. The profits which can be derived through agricultural pursuits at least equal those of any other State, and where intensive farming under irrigation is practiced these profits so far exceed those obtained in the Eastern States as to be beyond belief by those not familiar with western conditions. With nearly one-third of the State vacant, and subject to entry under the public-land laws of the United States, it can readily be understood why land values are low. The value of land is more dependent on the convenience of transportation facilities than on its ability to produce.

Silver Lake post-office, in the northern part of Lake County, has the distinction of being farther from railway transportation than any other office in the United States. In 1906 there was within Lake, Harney, and Malheur counties an area of vacant public land almost equal to the combined areas of New Jersey, Massachusetts, and Connecticut. This vast territory is without transportation, not because the land is worthless, but owing to a peculiar combination whereby the West was divided between the different railway interests. But

a change in policy has taken place. The Northern Pacific has just completed and put into operation a high-class road from Spokane to Portland, and it is expected a branch line up the Deschutes River will be constructed soon. The owners of the electric lines now being extended through the Willamette Valley have announced plans for extending lines over the mountains. It has been announced that the Union Pacific is now ready to begin the extension of relief.

Over 250,000 acres have been selected by the State in Crook County for reclamation under the Carey Act. On the Deschutes Irrigation and Power Company's project, near Bend, over 600 tracts, averaging about 60 acres each, have been sold. During the past three years Agency Plain, 8 by 20 miles in extent, along the Deschutes, half way between Bend and Shaniko, has been homesteaded for dry-farming purposes. During 1907 it is reported that over 1,500,000 bushels of wheat were produced from the first year's crop. It thus appears that even without irrigation the country is productive, and that the traffic in sight will justify the building of the necessary railway lines. The opportunities for settlement within this district are, therefore, almost unlimited.

With the completion of the North Bank Railroad, the construction at Portland of one of the largest packing establishments and stock yards in the West has been begun. A market for stock is thus assured.

In addition to the abundant opportunities of securing cheap land as outlined above, the opportunities for securing the necessary water supply, where irrigation is necessary, are believed to be still greater. Under the favorable legislation of many of the Western States, all of the available reservoir sites where storage can be provided at moderate expense have been taken up. In Oregon this class of development has been retarded owing largely to the unfavorable laws.

With the abundance of winter flood waters, as shown in the section on water resources, the opportunities for rapid development of irrigation in Oregon are believed to be great.

FUTURE DEVELOPMENT OF IRRIGATED FARMING.

Three factors will greatly affect the future of irrigated farming in Oregon: (1) Recent more favorable legislation concerning the use and distribution of water; (2) better transportation facilities for the undeveloped portion of the State; and (3) the employment of better methods in irrigated agriculture and a better understanding on the part of present landowners and of prospective settlers as to the need of irrigation in the different parts of the State.

INFLUENCE OF RECENT LEGISLATION.

The enactment, recently, of laws more favorable to the development and use of the water resources will materially promote the development of irrigated agriculture, and, indirectly, the prosperity of the State along all lines.

The irrigator can, under this law, secure immediate and permanent relief from the heretofore impossible task of protecting his own water supply. If his water is wrongfully taken by others above, he telephones to the water policeman, or water master, as he is called, and this public official, having the necessary authority, patrols the stream, closing all head gates, to admit only the amount each ditch is entitled to receive.

The relief which can be granted by the board of control will be immediate, as compared with the long delays under the old system, if the experience under a much similar law in Wyoming is any guide. After eighteen years in operation, practically all of the early rights in Wyoming have been determined, with but seven appeals to the courts. The most complicated case is decided within a year, and usually within less than six months. The cost under the Oregon law is small and fixed by law. The experience of the board in one case is carried to the next case, perhaps in another county or court jurisdiction. The order goes into effect immediately, whether or not the case is appealed.

The decision, when rendered, affords permanent relief. The rights of all claimants on the stream are determined. No new rights can be initiated without compliance with law, and when granted by the State they will be as definitely known and recorded as the early rights which are hereafter determined. These records serve as the basis for the State administrative system for the distribution of water, which system is the final purpose of the law.

The investor can, upon any adjudicated stream, ascertain definitely the amount of surplus water available for further appropriation. If there is any surplus, or if he desires to store water, a definite procedure is provided whereby he can acquire a right to the necessary water in advance of the construction of his plant. His right is protected during construction and definitely granted upon completion of his plans. He is thus able to transfer good title to settlers, and a prospective settler, under such a system, can purchase a water right intelligently and without fear of purchasing an unending lawsuit.

Under this law the wasting of water can be prevented. When the rights are once determined and the water master appointed there will be no further incentive for wasting a large flow of water in some porous spot in order to make sure of the necessary water supply when needed. If water is found wasting across the lower end of a tract, the head gate can be partially closed by the water master. This certainty

of rights and saving of water will materially extend the area which the various streams can serve. It will encourage the intelligent use of water and prevent the ruining of some land by alkali resulting from overirrigation.

A foundation in law for water rights having thus been established, rights to water will become of definite value. The unappropriated waters of the State will also have a definite value, depending upon the amount and the cost of putting to beneficial use. Prospective investors or settlers, seeing this value and finding large areas of vacant or cheap land, will be eager to appropriate such water. The protection of the water user and the simplicity and definiteness in acquiring new rights are the leading reasons for expecting rapid development in Oregon as a result of this legislation. This, together with the fact that the great water resources are comparatively undeveloped, because of the heretofore unfavorable laws, makes the opportunities at this time more favorable than they would have been had effective water laws been adopted earlier.

INFLUENCE OF BETTER TRANSPORTATION FACILITIES.

The influence of better transportation on the future development of irrigated farming in Oregon is self-evident. Railway or water transportation is absolutely necessary for production of certain crops on a large scale. The leading industry in central Oregon at the present time is the production of stock, because it can be driven long distances to railway transportation with but little expense. Such high-priced products as wool can be hauled out by wagon with profit, while wheat and other low-priced products of similar bulk can not be freighted by team from the interior with profit. The principal irrigated products of this region are therefore confined to hay and grain, which are necessary for the support of this stock. Flour mills are scattered through this district, but the consumption of wheat is limited by the local demand for flour.

The Interstate Commerce Commission reports that on June 30, 1906, Oregon had 2.01 miles of railway per 100 square miles of territory, as compared with 22.79 miles for Ohio. All mileage for Oregon is in the western and extreme northern parts of the State. With the building of a line up the Deschutes River and extending through to Nevada or California, a vast undeveloped territory will be opened to profitable settlement. Construction along this route seems the most probable at the present time. Another feasible route which has been surveyed and will be built ultimately is to connect the branch of the Oregon Short Line Railway recently completed between Ontario and Vale with the Corvallis and Eastern Railway

at Detroit. The surveys follow an easy grade up the Malheur River, passing near Burns, Silver Lake, Bend, Sisters, and over the mountains south of Mount Jefferson. This line has been graded most of the way from Detroit to the summit of the mountains and some heavy rock work has been done in the Malheur Canyon above Vale. A line has been surveyed from Eugene up the Middle Fork of the Willamette, crossing the mountains at Odell Lake, passing near Odell post-office, through Klamath Falls to a connection with the main line in California. This line will shorten materially the distance between Portland and San Francisco, will have easier grades than the present line, and will cut out a mountain division which is difficult to operate in the winter time. In addition to these advantages, much traffic can be secured from the Klamath region, which is being rapidly developed through the prospects of the early completion of the Government reclamation project. The California end of this cut-off is now being completed to near Klamath Falls. The cross-State road, if built, may connect with this line at Odell, instead of with the Corvallis and Eastern at Detroit.

The topographic features of central Oregon make these the important routes. The controlling feature in the north and south lines is the easy grades up the Deschutes River to the plateau region, with easy access through Klamath Falls to California, or through a pass near Lakeview. The light grades up the Malheur River to the plateau district is the controlling feature of the cross-State line.

The probably early construction of these lines has led to considerable activity in the interior during the past year. With their completion, the convenient access to the markets of the world and the cheapness with which supplies can be secured will cause the most expensive irrigation projects in this district to be rapidly developed and will create a new field for the practice of irrigated farming.

INFLUENCE OF BETTER METHODS OF FARMING.

Only a limited amount of work has been undertaken in Oregon in the matter of irrigation by the Department of Agriculture. There is urgent need for investigations to correct the idea that one miner's inch per acre is necessary for the proper irrigation of crops. At this rate it will require 1 cubic foot per second of water for the irrigation of 40 acres. There was in 1906 over 50 miles of ditches diverting water from Squaw Creek in Crook County. These have a total capacity of 237 cubic feet per second for 3,500 acres. The present ditch capacity from this stream is, therefore, 1 cubic foot per second for 15 acres, and there is not water enough for all. From an average of the statements of twenty-one water users, 1½ miner's inches per acre are now used. While much of the shortage complained of is due to lack of a proper method of distributing water from the stream, the main

difficulty comes from overirrigation. With a demonstration farm in this vicinity, it could probably be shown that greater yields could be secured by the application of less water. With all water rights defined and each irrigator assured of his water when needed, this stream could be made to serve two or three times the present area.

Measurement of three typical tracts irrigated from the Walla Walla River shows that 9, 17, and 22 acre-feet of water was actually applied to the growing crop during the irrigation season of 1906. If the average farmer in a humid climate had 22 feet or 264 inches of rainfall during the summer time, his place would doubtless be for sale in a short time. About 3 acre-feet per season is generally considered sufficient on average ground for most crops raised in this vicinity. Irrigators from the Walla Walla River have for years used excessive quantities of water, mainly to hold their right to the water supply, and they have come to believe they need all they apply. It could be demonstrated without doubt by further experimental work that by applying the rotation system and by each person using a large volume of water for a short period of time, better results could be accomplished with a great saving of water. The present system of furrow irrigation with a small stream on porous ground doubtless explains the excessive amount reported above.

Overirrigation, or the wasting of this natural resource, is an evil that the State is vitally interested in. Where water is found to be wasting across the lower edge of an irrigated tract, a State officer is now authorized to close the head gate and permit the wasting water to flow down the stream to other lands.

With the adoption of State control of diversions, a uniform method of measuring water can be put into practice along the streams of the State. This will lead to the adoption of the same system for distributing water from the various canals, which in turn will lead to a better understanding on the part of the irrigator as to units of volume and rate of flow and cause a more intelligent and scientific use of water.

Along the Walla Walla River the perpetual right to the water which will flow through a trough 1 foot wide, 1 foot deep, and at the rate of 1 foot per second is worth at least $10,000, yet many believe water has no value and that one should be allowed to divert it at will from the stream without consideration of the rights of others.

Experimental information as to the minimum quantity of water required for the growing of crops in the great undeveloped section of central Oregon would be of great assistance to the prospective settler. The boring of a single test well at public expense in each of the basins where indications are favorable to the securing of artesian water would also do much for the irrigation development of this region.

No more fertile field for the future development of irrigated agriculture on a large scale exists in Oregon than the Willamette Valley.

But few farmers in this district have had the courage to withstand the taunts of their neighbors concerning their experiments with irrigation. A great deal of energy is expended in the cultivation of certain crops by dry-farming methods for the conservation of moisture, when water, if available, could perhaps be applied at less expense.

The statistics of the U. S. Weather Bureau show the total annual rainfall in the Willamette Valley, taking Eugene as representative, to be less than that which occurs at many of the important cities of the Eastern States.

Annual rainfall at Eugene compared with important cities.

City.	Precipitation June, July, and August.	Annual precipitation.	City.	Precipitation June, July, and August.	Annual precipitation.
	Inches.	*Inches.*		*Inches.*	*Inches.*
Eugene, Oreg.	2.6	37.4	Charleston, S. C.	20.1	53.4
Chicago, Ill.	10.1	33.4	New Orleans, La.	18.2	57.6
New York, N. Y.	12.3	44.8			

The above table shows that the total annual precipitation at Eugene is but little greater than at Chicago and much less than that for New York, Charleston, and New Orleans. The striking feature brought

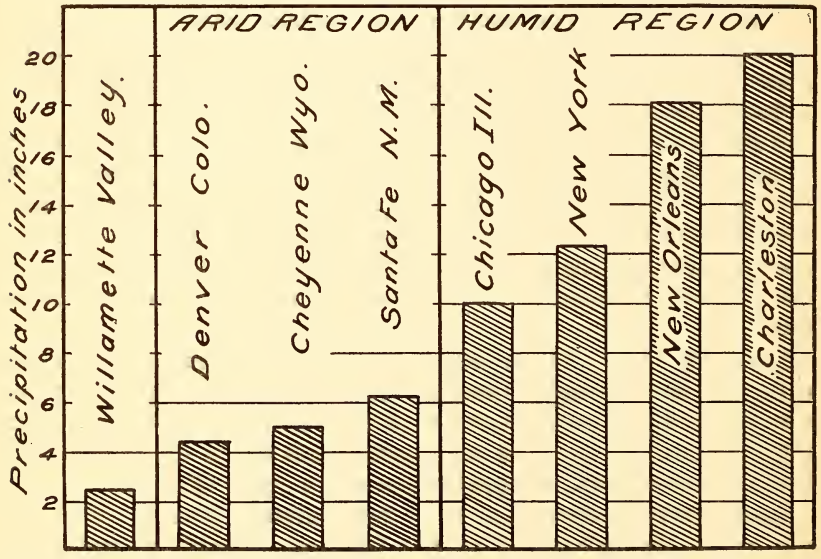

FIG. 7.—Precipitation in the Willamette Valley during June, July, and August as compared with other points.

out by the table is that during June, July, and August at Eugene the average rainfall amounts to only 2.6 inches, as compared with 10.1 inches for Chicago and 20.1 inches for Charleston.

Figure 7 shows graphically perhaps a more striking condition, when the summer rainfall in the Willamette Valley is compared with that which occurs at certain points in the arid States, where irrigation is admitted to be absolutely essential to successful farming. The average precipitation at Corvallis during June, July, and August amounts to 1.8 inches and at Eugene 2.6 inches, as compared with 4.4 inches at Denver, Colo., 5 inches at Cheyenne, Wyo., and 6.2 inches at Santa Fe, N. Mex. It is thus apparent that the Willamette Valley can not be considered as having a humid climate, so far as summer precipitation is concerned, and that it is even more arid than some

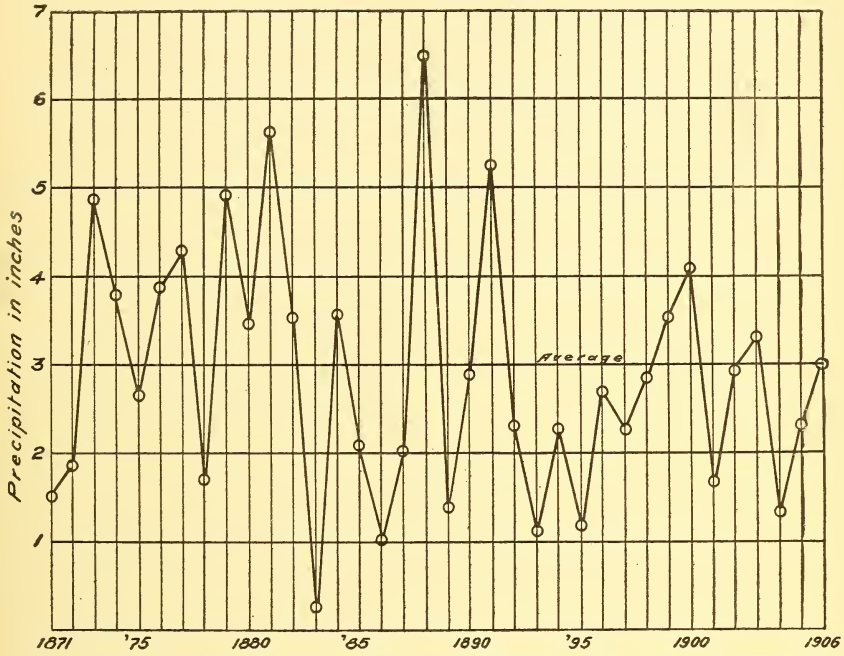

FIG. 8.—Total precipitation at Portland, during June, July, and August, 1871–1906.

points in what are generally considered the arid States. The summer precipitation at Baker City (2.3 inches), La Grande (2.7 inches), and Joseph (3.4 inches), all in the eastern or arid portion of the State where irrigation is practiced, is greater than it is at Salem (2.2 inches) in western Oregon.

The graphical presentation of the monthly precipitation at Portland (fig. 3, p. 11), which is typical of the Willamette Valley, shows clearly the division of the year into distinctly wet and dry periods. Of a total of 45.6 inches annual precipitation, 43.8 per cent falls during the winter months, 23.5 per cent during the spring months, 6.6 per cent during the summer, and 26.1 per cent during the fall. The

annual variations which occur in the 3 inches of summer precipitation at Portland is shown for a period of thirty-six years by figure 8. In 1883 less than 0.3 of an inch of moisture fell during the best three months of growing weather in this valley. During practically twelve years of this period there was 2 inches or less per year during the summer months. During all this time there were but three years when the summer precipitation was greater than 5 inches.

In the production of crops it is not the total rainfall that governs, but, rather, its distribution. If it is less expensive and equally efficient to conserve the excess winter and spring moisture to supply the summer deficiency than it is to irrigate, irrigation is not necessary. To prove this proposition to the satisfaction of the present landowners in this valley will require actual demonstration on a practical scale. This the Office of Experiment stations, U. S. Department of Agriculture, has undertaken in a limited way, and some definite results have been reported for the season of 1907.[a] These are, in part, as follows:

Yields of irrigated and unirrigated potatoes and corn at Corvallis, Oreg.

Treatment.	Yield of tubers per acre.	Increase.	Marketable tubers.	Green fodder per acre.	Increase.
	Pounds.	*Per cent.*	*Per cent.*	*Pounds.*	*Per cent.*
Unirrigated	2,604	.....	89.2	5,647	.....
Irrigated once	6,760	160	88.0	7,000	24
Irrigated twice	7,500	180	93.2	9,666	71

Yield of irrigated and unirrigated onions at Philomath, Oreg.

	Pounds.
Yield from 24 irrigated rows	850
Yield from 24 unirrigated rows	350
Increase	500

Mr. Oswald West, near Corvallis, Oreg., has irrigated hops by pumping from the Willamette River, and reports that the yield can be increased 75 to 100 per cent through irrigation.

The conclusions of this first progress report on irrigation experiments in the Willamette Valley are as follows:

The evidence presented, though fragmentary and incomplete, indicates the need of irrigation in the valley and that it will be of benefit in the following ways:

(1) It will serve as crop insurance for those crops which in ordinary years are matured before the dry season, but suffer during exceptional periods of early drought.

(2) The mild climate makes it possible for the dairy herd to secure food during all seasons of the year except the summer, but under present conditions

[a] U. S. Dept. Agr., Office of Experiment Stations Circ. 78.

it is necessary to feed them either dry feed or silage during the summer months when pastures are dried up. Irrigation will produce green food during this dry period and will make it possible to carry the herd into the winter season in full milk.

(3) The market-garden industry is coming to depend upon irrigation for its fullest development, and already in many cases market gardeners have provided themselves with a small water supply which they use in the production of late crops of vegetables which could not be matured without it. These late vegetables and berries go on the market when the earlier crops have become exhausted. This is especially true of such vegetables as celery, cauliflower, and potatoes.

(4) Both irrigation and drainage will doubtless be of service in reclaiming a vast area of prairie land which, owing to its poor natural drainage and to the abuse it has received in grain cultivation, lies in a water-logged condition till late in the spring, and which, even when cultivated and subsoiled, is wholly incapable of producing normal crops. Drainage of these lands will relieve their water-logged condition and make them more responsive to cultivation, while irrigation will carry the crops grown on them through the dry period.

This valley is approximately 150 miles in length by 50 to 75 in width, including the foothill lands. It is held in large holdings, which are comparatively unproductive. For many years wheat has been the principal product, because it matures early before its growth is stunted for lack of moisture. However, during the past thirty years the yield has diminished from 40 or 45 bushels per acre to 17 or 18 bushels, and the gluten content has fallen off slightly also. This explains somewhat the low values of land in this the most important agricultural section of the State.

Certain diversified industries are beginning to take the place of wheat production, but intensive farming by irrigation is not looked upon favorably by the pioneer. The extension of these experiments so as to give definite results as to the value of irrigation of different crops on a practical basis will do much both for the early adoption of the new method of agriculture by the present population of western Oregon and the settlement of the State by those seeking homes and profitable investments.

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